

Non-steroidal anti-inflammatory drugs (NSAIDs) are a group of unrelated chemical compounds that have been used to successfully treat rheumatic and musculoskeletal disease. Unfortunately, unwanted hepatotoxic side effects have led to the premature market withdrawal of several NSAIDs, including Cincophen, Benoxaprofen, Piroxicam, Suprofen, and Bromfenac. The pervasiveness of idiosyncratic reactions of many NSAIDs has led the Food and Drug Administration Arthritis Advisory Board to conclude that NSAIDs as a group should be considered to induce hepatotoxicity.

It is estimated that annual NSAIDS consumption in the U.S exceeds 10,000 tons. Due to this large consumption of NSAIDS for a wide variety of pain and inflammatory conditions, it has become an important class of drugs responsible for liver injury, despite the overall extremely low incidence of producing hepato-toxicity. Liver injury resulting from NSAIDs can have several forms, including acute toxicity resulting from hepatocellular (parenchymal) damage (*e.g.* necrosis) and arrested bile flow (cholestasis). Thee general mechanism that is thought to mediate NSAIDS toxicity is idiosyncratic reaction (Type II) to the drug (both immunologic and metabolic), which is dose independent, and presumably results from interindividual variation in drug metabolism. Currently no clear mechanism of drug-induced idiosyncratic toxicity is available. Accordingly, there remains a great need to elucidate the molecular basis of idiosyncratic hepatotoxicity, such as NSAID-induced toxicity, including the identification of genes and proteins differentially expressed in response to administration of such drugs.

SUMMARY OF THE INVENTION

In accordance with the present invention, there are provided methods of screening and identifying test agents which induce hepatotoxicity, *e.g.* idiosyncratic hepatotoxicity. The methods of the invention are based in part on the discovery that certain nucleic acids are differentially expressed in liver tissue of animals treated with NSAIDs. These differentially expressed nucleic acids include novel sequences that, while previously described, have not heretofore been identified as responsive to drugs, such as NSAIDs, which induce idiosyncratic hepatotoxicity.

In various aspects, the invention includes a method of screening a test agent for toxicity, *e.g.*, idiosyncratic hepatotoxicity. For example, in one aspect, the invention provides a method of identifying a hepatotoxic agent by providing a test cell population comprising a cell capable of expressing one or more nucleic acids sequences responsive to drugs, *e.g.* NSAIDs, which induce idiosyncratic hepatotoxicity, contacting the test cell population with the test agent and comparing the expression of the nucleic acids sequences in the test cell population to the expression of the nucleic acids sequences in a reference cell population. An alteration in expression of the nucleic acids sequences in the test cell population compared to the expression of the gene in the reference cell population indicates that the test agent is hepatotoxic. In one aspect, expression in

the test cell population is compared to the expression of a reference cell population exposed to a NSAID that is classified as low risk, very low risk, or overdose risk of hepatotoxicity, thereby to predict whether the test agent has low, very low, or overdose risk of hepatotoxicity. In another aspect, the test cell population is compared to the expression of a reference cell population exposed to a NSAID which induces a known type of hepatic injury, *e.g.* hepatocellular damage, cholestasis, or elevated transaminase level, thereby to predict whether the test agent is likely to induce a given type of hepatotoxic injury.

In a further aspect, the invention provides a method of assessing the hepatotoxicity, *e.g.* idiosyncratic hepatotoxicity, of a test agent in a subject. The method includes providing from the subject a cell population comprising a cell capable of expressing one or more NSAID-responsive genes, and comparing the expression of the nucleic acids sequences to the expression of the nucleic acids sequences in a reference cell population that includes cells from a subject whose exposure status to a hepatotoxic agent is known. An alteration in expression of the in the test cell population compared to the expression of the nucleic acids sequences in the reference cell population indicates the hepatotoxicity of the test agent in the subject.

Also provided are novel nucleic acids, as well as their encoded polypeptides, whose expression is responsive to the effects of NSAIDS.

Although methods and materials similar or equivalent to those described herein can be used in the practice or testing of the present invention, suitable methods and materials are described below. All publications, patent applications, patents, and other references mentioned herein are incorporated by reference in their entirety. In the case of conflict, the present specification, including definitions, will control. In addition, the materials, methods, and examples are illustrative only and not intended to be limiting.

DETAILED DESCRIPTION OF THE INVENTION

The invention is based in part on the discovery of nucleic acid sequences which are differentially expressed in rodent liver cells upon administration of NSAIDS. The discovery includes groups of nucleic acid sequences whose expression is correlated with hepatotoxicity risk associated with, and injury type induced by, NSAID administration.

The differentially expressed nucleic acid sequences were identified by examining 29 different NSAIDS that have varying degrees of hepatotoxicity. These 29 drugs, shown in Table 1, below, were first categorized as low dose (1-75 mg/kg) and high dose (above 75 mg/kg) drugs, then classified as non-toxic, toxic, and those withdrawn from market (within each dose). Each of the 29 NSAIDS was administered orally to groups (3 animals per group) of 12 week old male Sprague Dawley rats for 72 hours (3 days) at the dosages specified in Table 1 (e.g. Naproxen: 54 mg/kg/day PO in QD x 3 days in H₂O). Vehicle controls (water, ethanol, canola oil) were also included (3 animals per group). The animals were sacrificed 24 hours after the final dose, liver tissue was removed on necropsy, and total RNA was recovered from the dissected tissue. Complementary DNA (cDNA) was prepared and samples were processed through GENECALLING™ differential expression analysis, as described in U.S. Patent No. 5,871,697 and in Shimkets *et al.*, *Nature Biotechnology* 17: 798-803 (1999), the disclosures of which are hereby incorporated by reference herein.

Table 1: NSAIDS and Dosages Administered

Compound	Dose	Vehicle
<i>Acetaminophen</i>	133 mg/kg/day p.o. in QD x 3 days.	10 %Ethanol Vehicle
<i>Acetylsalicylic Acid</i>	200 mg/kg/day p.o. in QD x 3 days.	Canola Oil Vehicle
<i>Benoxaprofen</i>	16 mg/kg/day p.o. in QD x 3 days.	H2O Vehicle
<i>Bromfenac</i>	7.5 mg/kg/day p.o. in QD x 3 days.	H2O Vehicle
<i>Celecoxib</i>	89 mg/kg/day p.o. in QD x 3 days.	Canola Oil Vehicle
<i>Diclofenac</i>	38 mg/kg/day p.o. in QD x 3 days.	H2O Vehicle
<i>Etodolac</i>	30 mg/kg/day p.o. in QD x 3 days.	10% Ethanol Vehicle
<i>Felbinac</i>	33 mg/kg/day p.o. in QD x 3 days.	Canola Oil Vehicle
<i>Fenoprofen</i>	154 mg/kg/day p.o. in QD x 3 days.	Canola Oil Vehicle
<i>Flurbiprofen</i>	10 mg/kg/day p.o. in QD x 3 days.	Canola Oil Vehicle
<i>Ibuprofen</i>	211 mg/kg/day p.o. in QD x 3 days.	H2O Vehicle
<i>Indomethacin</i>	4 mg/kg/day p.o. in QD x 3 days.	Canola Oil Vehicle
<i>Ketoprofen</i>	10 mg/kg/day p.o. in QD x 3 days.	Canola Oil Vehicle
<i>Ketorolac</i>	1.5 mg/kg/day p.o. in QD x 3 days.	10% Ethanol Vehicle
<i>Meclofenamate</i>	20 mg/kg/day p.o.in QD x 3 days.	H2O Vehicle

<i>Mefenamic Acid</i>	79 mg/kg/day p.o. in QD x 3 days.	Canola Oil Vehicle
<i>Nabumetone</i>	143 mg/kg/day p.o. in QD x 3 days.	Canola Oil Vehicle
<i>Naproxen</i>	54 mg/kg/day p.o. in QD x 3 days.	10% Ethanol Vehicle
<i>Olsalazine</i>	222 mg/kg/day p.o. in QD x 3 days.	H2O Vehicle
<i>Oxaprozin</i>	100 mg/kg/day p.o. in QD x 3 days.	Canola Oil Vehicle
<i>Phenacetin</i>	100 mg/kg/day p.o. in QD x 3 days.	Canola Oil Vehicle
<i>Phenylbutazone</i>	100 mg/kg/day p.o. in QD x 3 days.	Canola Oil Vehicle
<i>Piroxicam</i>	20 mg/kg/day p.o. in QD x 3 days.	Canola Oil Vehicle
<i>Sulindac</i>	77 mg/kg/day p.o. in QD x 3 days.	Canola Oil Vehicle
<i>Sulphasalazine</i>	338 mg/kg/day p.o. in QD x 3 days.	Canola Oil Vehicle
<i>Suprofen</i>	20 mg/kg/day p.o. in QD x 3 days.	Canola Oil Vehicle
<i>Tenoxicam</i>	10 mg/kg/day p.o. in QD x 3 days.	Canola Oil Vehicle
<i>Tolmentin</i>	100 mg/kg/day p.o. in QD x 3 days.	H2O Vehicle
<i>Zomepirac</i>	19 mg/kg/day p.o. in QD x 3 days.	Canola Oil Vehicle

3635 gene fragments were initially found to be differentially expressed in rat liver tissue (analysis of variance, $p < 0.01$) in response to these compounds. The compounds were then classified according to hepatotoxicity risk, as indicated in Table 2.

Table 2: Hepatotoxicity Risk of NSAIDs

Compound	Risk
Acetaminophen	Overdose Risk
Acetylsalicylic Acid	Overdose Risk
Benoxaprofen	Low Risk
Bromfenac	Low Risk
Celecoxib	Unknown
Diclofenac	Low Risk
Etodolac	Very Low Risk
Felbinac	Unknown
Fenoprofen	Very Low Risk
Flurbiprofen	Very Low Risk
Ibuprofen	Very Low Risk
Indomethacin	Very Low Risk
Ketoprofen	Very Low Risk
Ketorolac	Unknown

Meclofenamate	Very Low Risk
Mefenamic Acid	Very Low Risk
Nabumetone	Very Low Risk
Naproxen	Very Low Risk
Olsalazine	Unknown
Oxaprozin	Very Low Risk
Phenacetin	Overdose Risk
Phenylbutazone	Low Risk
Piroxicam	Very Low Risk
Sulindac	Low Risk
Sulphasalazine	Unknown
Suprofen	Very Low Risk
Tenoxicam	Very Low Risk
Tolmentin	Very Low Risk
Zomepirac	Very Low Risk

In order to discriminate among these groups, the above compound set was divided into a training set (consisting of three compounds per group), and a test set (consisting of the remainder. This was done to minimize the reliance on the assumptions required for parametric analyses. Compounds with unknown risk were not used in this analysis. The training set employed is shown in Table 3.

Table 3: Training Set of NSAIDs by Risk Classification

Control	Low Risk	Very Low Risk	Overdose Risk
Sterile water	Benoxaprofen	Flurbiprofen	Acetaminophen
10% Ethanol	Phenylbutazone	Oxaprozin	Acetylsalicylic Acid
Canola oil	Sulindac	Tenoxicam	Phenacetin

The 3635 differentially expressed nucleic acid fragments were then analyzed using a stepwise multivariate analysis of variance as follows:

1. Calculate 3635 T2 (yi1) (Hoettelling's trace, one of the test statistics used for this analysis) values, one for each differentially expressed fragment. The fragment with the largest individual T2 value is selected as the first discriminatory set (yi1).
2. Calculate 3634 T2 (yi1,yi2) values, one for each combination of two fragments. The fragment pair with the largest individual T2 value are selected as the second discriminatory set.

3. Calculate 3626 T2 ($y_{i1}, y_{i2}, y_{i3}, \dots, y_{i10}$), one for each combination of ten fragments.

The fragment set with the largest T2 value are selected as the final discriminatory set.

This stepwise procedure is used whenever the number of dependent variables (gene fragments) exceeds the number of independent variables (samples). In addition to fragment
5 addition, fragment elimination occurs whenever an added fragment no longer contributes significant discriminatory power to the existing set. This eliminates bias as to the order fragments enter the model (Ahrens and Lauter, Mehrdimensionale Varianzanalyse, Akademie-Verlag, Berlin (1974); Dziuda, *Medical Inform.* 15(4): 319 (1990)).

This analysis protocol identified ten fragments that significantly ($p=6.02 \times 10^{-28}$)
10 discriminated among the drugs in the test set. Two fragments on this list were not required to maintain the discriminatory ability and were subsequently removed ($p=3.96 \times 10^{-26}$). Differential expression of these gene fragments were successfully confirmed using an unlabeled oligonucleotide competition assay (Shimkets *et al.*, *Nature Biotechnology* 17: 198-803 (1999)). The 8 fragments (RISKMARKER 1-8) represent both novel and known rat genes for which the
15 sequence identity to genes in public databases is either high (>90%), moderate (70-90%), or low (<70%).

The identity of these 8 hepatotoxicity risk discriminatory nucleic acid sequences (with GenBank accession numbers) are further described below. Where appropriate, the cloned sequence from isolation is provided; this sequence was then extended using either Genbank rat
20 ESTs or from internally (Curagen Corporation) sequenced rat fragments. The extended contig sequence is provided as "consensus." Finally, the best BlastN and BlastX results are also provided. In some instances the cloned sequence is identical to a known rat gene, in those instances the name of the gene and a database accession number and the sequence listed in the database is provided:

25 RISKMARKER 1

RISKMARKER 1 is a novel 1265 bp gene fragment, which has 67% sequence identity to human *rac1* genomic fragment [AJ132695], probable 3' UTR. The nucleic acid was initially identified in a cloned fragment having the following sequence:

1 caattgaaaa aagtttgttc tagtggtcga aaggcccaac actgtgttct tgccagtga

70

5 Query: 66 ATAAATCCTTGAATCATAAAAAATGCTTTGGAAGTGAAGAAAAA 10
ATAAAT|TTGAAT|ATA A AA A TGT TTTG A|TTGA AA AA
Sbjct: 28092 ATAAATCCTTGAATCATACGACTGGTAATACTGGTGTTTTGGAGACTGATGAACAA 28148

10 RISKMARKER2 is a 650 bp rat expressed sequence tag (EST) [AW435096]. The
nucleic acid sequence was initially identified in a cloned fragment having the following
sequence:

1 TTTT'TTTTTTTTTTTTTTGGCAGAATTCTGATGTTTACTGGGACCCATAGTAGTCAAGGTGACAGCAAGGGTAGGGGAGGA
81 AACTCAGCAGAGGCGGATCCCAGGTCTGGAGGGAAGCTGACAGCAGCCCAGTAAGCTGTGCCAGAAGGCTGTAAACAGTAG
161 CGGAGCCAGTGACAGCGCCAGGCTGGGCTGGGTTCTCTCTGTGGGTGTGCACGGCAAAGCTGCCGCCCTGTGGGCCCTGGG
241 GGGCCTGTCACTCCACATCCACCACATGCATGTCGGTGAGGCTAAGGTCAGCCACAAGCACCCCCAATGACACGATCAA
321 GCCTAGACTGGGAGCGGCCAGGGCAGCGGCTGCCATGGTGTGGAGTTTCGGGGGGCCAAGGGGCAGAGCCCACGCACAG
401 GGCCCTCATAGAGCACTGTGCGGGGCCACTACTATGTGCGGCAGCCAGGGGTCNCTCCAGCCGGAAGCCATCAGGATGT
481 GTGG (SEQ ID NO: 3)

The cloned sequence was assembled into a contig resulting in the following consensus sequence:

1 TTTTTTTTTTTTTTTTTGGCAGAATTCTGATGTTTACTGGGACCCATAGTAGTCAAGGTGACAGCAAGGGTAGGGGAGGA
81 AACTCAGCAGAGGCGGATCCCAGGTCTGGAGGGAAGCTGACAGCAGCCCAGTAAGCTGTGCCAGAAGGCTGTAACAGTAG
161 CGGAGCCAGTGACAGCGCCAGGCTGGGCTGGGTTCTCTCTGTGGGTGTGCACGGCAAAGCTGCGGCCTGTGGGCCCTGGG
241 GGGCCTGTCTAGCTCCACATCCACCACATGCATGTCGGTGAGGCTAAGGTCTAGCCACAAGCACCCCAATGACACGATCAA
321 GCCTAGACTGGGAGCGGCCAGGGCAGCGGCTGCCATGGTGTGGAGTTTCGGGGGGCCAAGGGGCAGAGCCCACGCACAG
401 GGCCCTCATAGAGCACTGTGCGGGGCCCACTACTATGTGCGGCAGCCAGGGGTCCCTCCAGCCGGAAGCCATCAGGATGT
481 GTGGCCATGGTGACTCGAAGGCTCTGGAGGCCCTCCGGCTGCATCCAATCTGCTGATGTCTTCACAACCCACAGGGCCCC
561 TCGGGCCACAAACACCGTGTGGCCCCAGTGGTTTGAAGCCTCCAGGAGCTGCCGCTCTGTGGTCTGGTCAGCGAGAGCTG
641 AGGGGGATCC (SEQ ID NO: 4)

20

>gb:GENBANK-ID:AW435096|acc:AW435096 UI-R-BJ0p-afy-e-10-0-UI.s1 UI-R-BJ0p
Rattus norvegicus cDNA clone UI-R-BJ0p-afy-e-10-0-UI 3', mRNA sequence -
Rattus norvegicus, 484 bp (RNA).
Length = 484

Plus Strand HSPs:

RISKMARKER3 is a 1019 nucleotide sequence encoding superoxide dismutase copper chaperone [AF255305]:

1	ggctctctgga	ccctaccggt	tgtgtggccc	aagcgggtga	ctgcagccag	gatggcttcg
61	aagtcggggg	acggtggaac	tatgtgtgcg	ttggagttta	cagtacagat	gagttgtcag
5	121	agctgcgtgg	acgctgtgca	caagaccctg	aaaggggagg	cgggtgtcca
	181	gttcagttgg	agaaccagat	ggtgttggtg	cagaccactt	tgccagcca
	241	gcgtcctgg	aaagcacagg	gaggcaggct	gtactcaagg	gcatgggcag
	301	aagaatctgg	gagcagcagt	ggccattatg	gagggcagtg	gcaccgtaca
	361	cgcttctctac	agctgtctctc	tgagctctgc	ctgattgagg	gaaccatcga
10	421	cctgggctgc	atgggcttca	tgtccatcag	tatggggacc	ttaccaagga
	481	tgtggggacc	attttaaccc	tgatggagca	tctcatgggg	gtcctcagga
	541	caccggggag	atctgggcaa	tgttcacgct	gaagctagt	gccgagctac
	601	gaggataaac	agctgaagg	gtgggatgtg	attggccgca	gtctggttgt
	661	gaagatgacc	tgggccgggg	aggccatccc	ttatccaagg	tcacagggaa
15	721	aggttggcct	gtggcatcat	tgacgctct	gctggccttt	tccagaatcc
	781	tgctcctgtg	atgggctcac	tatctgggag	gagcgaggcc	ggccattg
	841	cgaaaggact	cagcccaacc	ccctgctcac	ctctgaacag	agcctcctgt
	901	agtctctcta	gctgaacatc	ttctgacaga	gggagcctca	agccttctgt
	961	taaagggcag	ataggcattg	ttgtatcctg	agcaaattaa	attgttactc

RISKMARKER4

RISKMARKER4 is a 878 nucleotide sequence encoding alpha-2 microglobulin [U31287]:

1	ggcagcagca	gagagattgt	cccaacagag	aggcaattct	attccctacc	aacatgaagc
61	tggtgctgct	gctgctgtgt	ctgggcctga	caactggctg	tgcccatgca	gaagaagcta
121	gttccacaag	agggaaacctc	gatgtggcta	agctcaatgg	ggattgggtt	tctattgtcg
181	tggcctctaa	caaaagagaa	aagatagaag	agaatggcag	catgagagtt	tttatgcagc
241	acatcgatgt	cttggagaat	tccttaggct	tcaagtccg	tattaaggaa	aatggagagt
301	gcagggaact	atatttggtt	ccctacaaaa	gccagagga	tgccgaatat	ttgttgagt
361	atgacggagg	gaatacattt	actatactta	agacagacta	tgacagatat	gtcatgttct
421	atctcattaa	tttcaagaac	ggggaaacct	tccagctgat	ggtgctctac	ggcagaacaa
481	aggatctgag	ttcagacatc	aaggaaaagt	ttgcaaaact	atgtgaggcg	catggaatca
541	ctagggacaa	tatcattgat	ctaaccaaga	ctgatcgctg	tctccaggcc	cgaggatgaa
601	gaaaggcctg	agcctccagt	gctgagtggg	gacttctcac	caggactcta	gcataccat
661	ttctgtcca	tgagacatcc	tgagacaaat	tctgcatct	gatttccatc	ctctgtcaca
721	gaaaagtgca	atcctgggtct	ctccagcatc	ttccctaggt	taccaggagc	aacacatcga
781	gaattaaaag	ctttcttaaa	tttctcttgg	ccccacccat	gatcattccg	cacaaatatc
841	ttgctcttgc	agttcaataa	atgattaccc	ttgcactt		

RISKMARKER5

RISKMARKER5 is a 2443 bp rat mRNA for Mx3 protein [X52713]. The nucleic acid was initially identified in a cloned fragment (having 100% sequence identity to the rat mRNA) having the following sequence:

1 CCATGGATGAAATCTTCCAGCATCTGAATGCCTACCGCCAGGAGGCTCACAACTGCATCTCCAGCCACATTCCATTGATC
 81 ATCCAGTATTTTCATCTTGAAGATGTTTGCTGAGAAGCTGCAGAAGGGCATGCTCCAGCTCCTGCAGGACAAGGATTCCTG
 161 CAGCTGGCTCCTGAAGGAAAAGAGTGACACCAAGTGAAGAGGAGATTCTGAAGGAGCGGTTGGCAAGGCTGGCCCAAG
 241 CTCAGCGCAGGCTAGC (SEQ ID NO: 5)

Blast-N Results:

>gb:GENBANK-ID:RNMX3|acc:X52713 Rat mRNA for Mx3 protein - Rattus norvegicus, 2443 bp.

Top Previous Match Next Match
 Length = 2443

Plus Strand HSPs:

Score = 1280 (192.1 bits), Expect = 9.5e-52, P = 9.5e-52
 Identities = 256/256 (100%), Positives = 256/256 (100%), Strand = Plus / Plus

Query: 1 CCATGGATGAAATCTTCCAGCATCTGAATGCCTACCGCCAGGAGGCTCACAACTGCATCT 60
 |||||
 Sbjct: 1710 CCATGGATGAAATCTTCCAGCATCTGAATGCCTACCGCCAGGAGGCTCACAACTGCATCT 1769
 Query: 61 CCAGCCACATTCCATTGATCATCCAGTATTTTCATCTTGAAGATGTTTGCTGAGAAGCTGC 120
 |||||
 Sbjct: 1770 CCAGCCACATTCCATTGATCATCCAGTATTTTCATCTTGAAGATGTTTGCTGAGAAGCTGC 1829
 Query: 121 AGAAGGGCATGCTCCAGCTCCTGCAGGACAAGGATTCCTGCAGCTGGCTCCTGAAGGAAA 180
 |||||
 Sbjct: 1830 AGAAGGGCATGCTCCAGCTCCTGCAGGACAAGGATTCCTGCAGCTGGCTCCTGAAGGAAA 1889
 Query: 181 AGAGTGACACCAAGTGAAGAGGAGATTCTGAAGGAGCGGTTGGCAAGGCTGGCCCAAG 240
 |||||
 Sbjct: 1890 AGAGTGACACCAAGTGAAGAGGAGATTCTGAAGGAGCGGTTGGCAAGGCTGGCCCAAG 1949
 Query: 241 CTCAGCGCAGGCTAGC 256
 |||||
 Sbjct: 1950 CTCAGCGCAGGCTAGC 1965

Blast-X Results:

>ptnr:SWISSPROT-ACC:P18590 INTERFERON-INDUCED GTP-BINDING PROTEIN MX3 - Rattus norvegicus (Rat), 659 aa.

Top Previous Match Next Match
 Length = 659

Plus Strand HSPs:

Score = 429 (151.0 bits), Expect = 5.3e-39, P = 5.3e-39
 Identities = 84/84 (100%), Positives = 84/84 (100%), Frame = +3

Query: 3 MDEIFQHLNAYRQEAHNCISSHIPLIIQYFILKMF AEKLQK GMLQLLQDKDSCSWLLKEK 182
 MDEIFQHLNAYRQEAHNCISSHIPLIIQYFILKMF AEKLQK GMLQLLQDKDSCSWLLKEK
 Sbjct: 571 MDEIFQHLNAYRQEAHNCISSHIPLIIQYFILKMF AEKLQK GMLQLLQDKDSCSWLLKEK 630
 Query: 183 SDTSEKRRFLKERLARLAQAQRRL 254
 SDTSEKRRFLKERLARLAQAQRRL
 Sbjct: 631 SDTSEKRRFLKERLARLAQAQRRL 654

0571331-11000

RISKMARKER6

RISKMARKER6 is 369 bp novel gene fragment, which has 98% amino acid identity (90% nucleic acid sequence identity) to Human ERj3 protein [AJ250137]. The nucleic acid sequence was initially identified in a cloned fragment having the following sequence:

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1 TCTAGAAAGTCACCTTGAAGAAGGTACGCGAGGGAACCTTGTGGAAGTAGTTAGAAACAAGCCGTAGCCAGGCAGGCT
81 CCTGGCAAACGGAATGCAACTGTCGGCAGGAGATGCGAACCACACAGCTGGGACCAGGGCGCTTCCAAATGACCCAGGA
161 AGTGGTTTGTGACGAGTGCCCTAATGTCAAAGTAGTGAATGAAGAACGAACACTAGAAGTGGAAATAGAGCCTGGGGTGA
241 GAGATGGCATGGAGTACCCCTTTATTGGAGAAGGTGAGCCTCATGTGGATGGGGAACCCGAGACTTACGGTTCCGAATC
321 AAAGTTGTCAAGCACCGGATATTTGAGAGGAGAGGGGATGACCTGTACA (SEQ ID NO: 6)
```

Blast-N Results:

>gb:GENBANK-ID:HSA250137|acc:AJ250137 Homo sapiens mRNA for ERj3 protein (ERj3 gene) - Homo sapiens, 1159 bp.

Top Previous Match Next Match
Length = 1159

Plus Strand HSPs:

Score = 1524 (228.7 bits), Expect = 5.6e-63, P = 5.6e-63
Identities = 334/369 (90%), Positives = 334/369 (90%), Strand = Plus / Plus

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Query: 1 TCTAGAAAGTCACCTTGAAGAAGGTACGCGAGGGAACCTTGTGGAAGTAGTTAGAAACA 60
      TCTAGAA GTCAC TTGGAAGAAAGT TA GCAGG AA TTGTGGAAGTAGTTAGAAACA
Sbjct: 431 TCTAGAA-GTCACTTTGGAAGAAGTATATGCAGGAAATTTGTGGAAGTAGTTAGAAACA 489

Query: 61 AGCCCGTAGCCAGGCAGGCTCCTGGCAAACGGAATGCAACTGTCGGCAGGAGATGCGAA 120
      A CC GT GC AGGCAGGCTCCTGGCAAACGGA TGCAA TGTCGGCA GAGATGCG A
Sbjct: 490 AACCTGTGGCAAGGCAGGCTCCTGGCAAACGGAAGTGCAATTGTCGGCAAGAGATGCGGA 549

Query: 121 CCACACAGCTGGGACCAGGGCGCTTCCAAATGACCCAGGAAGTGGTTTGTGACGAGTGCC 180
      CCAC CAGCTGGG CC GGGCGCTTCCAAATGACCCAGGA GTGGT TG GACGA TGCC
Sbjct: 550 CCACCCAGCTGGGCCCTGGGCGCTTCCAAATGACCCAGGAGGTGGTCTGCGACGAATGCC 609

Query: 181 CTAATGTCAAAGTAGTGAATGAAGAACGAACACTAGAAGTGGAAATAGAGCCTGGGGTGA 240
      CTAATGTCAAAGTAGTGAATGAAGAACGAAC CT GAAGT GAAATAGAGCCTGGGGTGA
Sbjct: 610 CTAATGTCAAAGTAGTGAATGAAGAACGAACGCTGGAAGTAGAAATAGAGCCTGGGGTGA 669

Query: 241 GAGATGGCATGGAGTACCCCTTTATTGGAGAAGGTGAGCCTCATGTGGATGGGGAACCCG 300
      GAGA GGCATGGAGTACCCCTTTATTGGAGAAGGTGAGCCTCA GTGGATGGGGA CC G
Sbjct: 670 GAGACGGCATGGAGTACCCCTTTATTGGAGAAGGTGAGCCTCACGTGGATGGGAGCCTG 729

Query: 301 GAGACTTACGGTTCCGAATCAAAGTTGTCAAGCACCGGATATTTGAGAGGAGAGGGGATG 360
      GAGA TTACGGTTCCGAATCAAAGTTGTCAAGCACC ATATTTGA AGGAGAGG GATG
Sbjct: 730 GAGATTACGGTTCCGAATCAAAGTTGTCAAGCACCAATATTTGAAAGGAGAGGAGATG 789

Query: 361 ACCTGTACA 369
      A TGTACA
Sbjct: 790 ATTTGTACA 798
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Blast-X Results:

>ptnr:SPTREMBL-ACC:Q9UBS4 ERJ3 PROTEIN PRECURSOR - Homo sapiens (Human), 358 aa.

Top Previous Match Next Match
Length = 358

Plus Strand HSPs:

Score = 637 (224.2 bits), Expect = 2.1e-61, P = 2.1e-61
Identities = 119/121 (98%), Positives = 120/121 (99%), Frame = +3

Query: 6 KVTLEEVYAGNFVEVVRNKPVARQAPGKRKCNCRQEMRTTQLGPGRFQMTQEVVCDECPN 185
+VTLEEVYAGNFVEVVRNKPVARQAPGKRKCNCRQEMRTTQLGPGRFQMTQEVVCDECPN
Sbjct: 139 EVTLEEVYAGNFVEVVRNKPVARQAPGKRKCNCRQEMRTTQLGPGRFQMTQEVVCDECPN 198

Query: 186 VKLVNEERTLEVEIEPGVRDGMETPFIFEGEPHVDGEPGDLRFRIKVVKHIFERRGDDL 365
VKLVNEERTLEVEIEPGVRDGMETPFIFEGEPHVDGEPGDLRFRIKVVKH IFERRGDDL
Sbjct: 199 VKLVNEERTLEVEIEPGVRDGMETPFIFEGEPHVDGEPGDLRFRIKVVKHIFERRGDDL 258

Query: 366 Y 368
Y
Sbjct: 259 Y 259

RISKMARKER7

RISKMARKER7 is a 594 bp novel gene fragment, which has 65% sequence identity to *Mus musculus* hexokinase II [AJ238540], probable 3' UTR. The nucleic acid sequence was initially identified in a cloned fragment having the following sequence:

1 GGGCCCCACTAAACATACACAAAAGAATAAAATGTTCAATTTAAACTTAACTGCTTCTGGTTTTACAAGGCATAAA
81 TATATAGCATCTCCAACAGCTACCTGTAGATTCTGTTAGTGCAAAACCTTAGAAACCTCCTGGAGCTCAAAGGCATCCG
161 GACTAGT (SEQ ID NO: 7)

The cloned sequence was assembled into a contig resulting in the following consensus sequence:

1 TTTTTTTTTTTTTTTTAAAAAAGATTATAAAATTGAATTTATTGAGTTTCACACAAGATGCACTTATAAAATTAGTACT
81 GAATGCCATTATGACAGAAGTGAGCATCATCCACTCCCAAGAGCATCTGCAAAGGAAATCAATCTTCAGAGAATAGCA
161 CAGAAACAGAAAATCCAAGCGAACAAAAAGATACATCTAGGCCGTGTTCTTGTCTGACCAGGGCCGCATTGGCAAAGC
241 TTTCTCTGCACCTCCCCTGGTTGCCAAGGATACTTTCTTTTGTAAAAAAGTTAGAAAGTGGGGCCCCACTAAAC
321 ATACACAAAAGAATAAAATGTTCAATTTAAACTTAACTGCTTCTGGTTTTACAAGGCATAAATATATAGCATCTCCA
401 ACAGCTACCTGTAGATTCTGTTAGTGCAAAACCTTAGAAACCTCCTGGAGCTCAAAGGCATCCGGACTAGTTTTGTACT
481 TAAACAGGATACGGGTAAACCACTTAAATTTGCCATCTCTGCCCAAAGTGTTCATGAGAACTGAGTTTCAGAAGACA
561 GCATAGGAAAGAGTCAGAAACGGTCAACTTTTTT (SEQ ID NO: 8)

Blast-N Results:

>gb:GENBANK-ID:MMU238540|acc:AJ238540 *Mus musculus* mRNA for hexokinase II - *Mus musculus*, 5474 bp.

Top Previous Match Next Match
Length = 5474

Minus Strand HSPs:

Score = 251 (37.7 bits), Expect = 0.045, P = 0.044
Identities = 121/184 (65%), Positives = 121/184 (65%), Strand = Minus / Plus

Query: 184 GTTCGCTGGATTTT-CTG-TTCTGTGCTATTCTCTGAAGATT-GATTTCTTTGCAGA 128
G TC CT G T T CTG TTT TGTG T TTC TGAA TT GA T C T T CA A
Sbjct: 5287 GCTCTCTCTGCTAATGCTGCTTTGTGTGATCTTCAGTGAACCTTTGACT-CATCT-CATA 5344

Query: 127 TGCTCTTGGGAGTGTGGATGATGCTCACTTCTGTCTAATGG-CATTC-AGTACTAATTT 70
T C CT GG A T G T TG C TT TGTCAT ATG CA T AG ACTA TT
Sbjct: 5345 TCC-CTGGGCACTCGGTCTAGTGAGCGTTT-TGTCATCATGTACAGTAGAGAACTAGTTG 5402

Query: 69 TATAAGTGCATCTTGTGTGAAACTCA-ATAAATTC AATTTTATAATCTTTTTTAAAAAAA 11
AT A CAT T TGT AA CT AT AAT AATTTTA T TTTTTT AAAAAA
Sbjct: 5403 AATTAAC-CATGTGATGTTAA-CTATTATTAATA-AATTTTAACTTTTTTTTCAAAAAA 5459

Query: 10 AAAAAAAAAA 1
AAAAAAAAAA
Sbjct: 5460 AAAAAAAAAA 5469

Score = 250 (37.5 bits), Expect = 0.051, P = 0.049
Identities = 122/184 (66%), Positives = 122/184 (66%), Strand = Minus / Plus

Query: 184 GTTCGCTGGATTTT-CTG-TTCTGTGCTATTCTCTGAAGATT-GATTTCTTTGCAGA 128
G TC CT G T T CTG TTT TGTG T TTC TGAA TT GA T C T T CA A
Sbjct: 5287 GCTCTCTCTGCTAATGCTGCTTTGTGTGATCTTCAGTGAACCTTTGACT-CATCT-CATA 5344

Query: 127 TGCTCTTGGGAGTGTGGATGATGCTCACTTCTGTCTAATGG-CATTC-AGTACTAATTT 70
T C CT GG A T G T TG C TT TGTCAT ATG CA T AG ACTA TT
Sbjct: 5345 TCC-CTGGGCACTCGGTCTAGTGAGCGTTT-TGTCATCATGTACAGTAGAGAACTAGTTG 5402

Query: 69 TATAAGTGCATCTTGTGTGAAACTCA-ATAAATTC AATTTTATAATCTTTTTT-AAAAA 12
AT A CAT T TGT AA CT AT AAT AATTTTA T TTTTTT AAAAAA
Sbjct: 5403 AATTAAC-CATGTGATGTTAA-CTATTATTAATA-AATTTTAACTTTTTTTTCAAAAAA 5459

Query: 11 AAAAAAAAAA 1
AAAAAAAAAA
Sbjct: 5460 AAAAAAAAAA 5470

Blast-X Results:

>ptnr:SPTREMBL-ACC:Q9VIA2 MST84DB PROTEIN - Drosophila melanogaster
(Fruit fly), 70 aa.

Top Previous Match Next Match
Length = 70

Plus Strand HSPs:

Score = 66 (23.2 bits), Expect = 2.2, P = 0.88
Identities = 15/48 (31%), Positives = 25/48 (52%), Frame = +3

Query: 66 YKISTECHYDRSEHHPHSQEHLQRKS-----IFRE*HRNRKSKRTKR 191
YK+ ++ H R +H P S++ RK I ++ RNRK R ++
Sbjct: 3 YKVHSHVKARMDHSPRSKDRKDRKGRKAHSHKHDIYSRNRKDHRVRK 50

RISKMARKER8

RISKMARKER8 is a 797 bp novel gene fragment, which has 94% amino acid identity (79% nucleic acid sequence identity) to human GT335 mRNA (ES1 Protein Homolog) [U53003]. The nucleic acid was initially identified in a cloned fragment having the following sequence:

1 CCTAGGACTGCACAACGTGAGTCTCTGAACCAGGCTCTGAAAAGGTGCCAGACCACCCAATGGGGACACACAGTGAGG

81 CCAGCCCCCAGTGAAATTCCTGCTGCTACCTGGGGCCCTTGGTGAGACTCTGGCTCCGGCTGGTAGAAGCCAAGGTTGG

161 ACGCATAGTTGCAAAGCTCCTCCTTCAGGCACAAAGTGTCTATGCTTCTAATAGAACAGCAGCTCCCGTGTCTGGCTGA
241 CCGGAGCACACAGGCTGAGCGTGCCACAGCGACGAGGAGCCAAAGCGTGGTGTCTGGTGGTGTACTTTCCCGTGAGTTC
321 CAGCACCTTCTTCACCATGG (SEQ ID NO: 9)

The cloned sequence was assembled into a contig resulting in the following consensus sequence:

1 TTTTTTTTTTTTTTTTTTTTTTTGAGTTTCCACTGTGGAAAAGAGTTTATTGTATGGCTGCAGGGATCTACTACAGAATCC
81 CCCTGGCTGCAGTTAGCTGTGCTTACTCTGGACATATCTCCGAAGACTTGGAGCCTAAATGGTTTTCTTCTTTAGAGCT
161 TTAGTACCCGATCCATCAGACCTAGGACTGCACAACGTGAGTCTTGAACCAGGCTCTGGAAAAGGTGCCAGACACCC
241 AATGGGGACACACAGTGAGGCCAGCCCCAGTGAAATTCCTGCTGTACCTGGGGCCCTTGGTGAGACTCTGGCTTCCGG
321 CTGGTAGAAGCCAAGGTTGGACGCATAGTTGCAAAGCTCCTCCTTCAGGCACAAAGTGTCTATGCTTCTAATAGAACAGC
401 AGCTCCCGTGTCTGGCTGACCGGAGCACACAGGCTGAGCGTGCCACAGCGACGAGGAGCCAAGCGTGGTGTCTGGTGG
481 TGTTACTTTCCCGTGAGTTCCAGCACCTTCTTCACCATGGCCCCAATCCCGTCGTGGATGTGGTGGAGTTCCGGTCTCACA
561 CATGAAGGCCGGGGTGGTGACCACTTGTTTTTCTGGTCGACGTGAGCTTCGGTCACACCCTTCACACAGTGCTTGGCAC
641 CCAGGGCTTTGACGGCTTCCGCGGTTCCAGCATATGGCCACTTGCCCCCTCCTCTTGCTCATGGCCCACGGTGACCTCC
ACACCTTTGATCACTTTGGCTGCGAGGACAGGAGCGATGCAGCATAGGCCAATGGGCTTCTTGGCTCCGTGGAATTC
721 (SEQ ID NO: 10)

Blast-N Results:

>gb:GENBANK-ID:HSU53003|acc:U53003 Human GT335 mRNA, complete cds - Homo sapiens, 1652 bp.

Top Previous Match Next Match
Length = 1652

Minus Strand HSPs:

Score = 1141 (171.2 bits), Expect = 7.9e-46, P = 7.9e-46
Identities = 307/385 (79%), Positives = 307/385 (79%), Strand = Minus / Plus

Query: 797 GAATTCCACGGAGCCAAGAAGCCCATGGCCTATGCTGCATCGCTCCTGTCTCGCAGCC 738
GA TTCCAC GCC GAAGCCCAT GGC T TGCTGCAT GC CCTGTCTCGC GCC
Sbjct: 577 GAGTTCACACAGGCCGGAAGCCCATCGGCTTGCTGCTGACCTGTCTCGCGGCC 636
Query: 737 AAAGTGATCAAAGGTGTGGAGGTCACCGTGGGCCATGAGCAAGAGGAGGGGGCAAGTGG 678
AA GTG TCA AGG GT GAGGT AC GTGGGCCA GAGCA GAGGA GG GGCAAGTGG
Sbjct: 637 AAGGTGCTCAGAGGCGTCGAGGTGACTGTGGGCCACGAGCAGGAGGAAGGTGGCAAGTGG 696
Query: 677 CCATATGCTGGAACCGCGGAAGCCGTCAAAGCCCTGGGTGCCAAGCACTGTGTGAAGGGT 618
CC TATGC GG ACCGC GA GCC TCAA GCCCTGGGTGCCAAGCACTG GTGAAGG
Sbjct: 697 CCTTATGCCGGGACCGCAGAGGCCATCAAGGCCCTGGGTGCCAAGCACTGCGTGAAGGAA 756
Query: 617 GTGACCGAAGCTCACGTGACCCAGAAAAACAAGGTGGTCACCAACCCCGGCCTTCATGTGT 558
GTG CGAAGCTCACGT GACCAGAAAAACAAGGTGGTCAC ACCCC GCCTTCATGTG
Sbjct: 757 GTGGTCAAGCTCACGTGGACCCAGAAAAACAAGGTGGTCACGACCCAGCCTTCATGTGC 816
Query: 557 GAGACCGAAGTCCACCATCCACGACGGGATTGGGGCCATGGTGAAGAAGGTGCTGGAA 498
GAGAC G ACTCCAC ACATCCA GA GGGAT GG GCCATGGTGA GAAGGTGCTGGAA
Sbjct: 817 GAGACGGCACTCCACTACATCCATGATGGGATCGGAGCCATGGTGAGGAAGGTGCTGGAA 876

Query: 497 CTCACGGGAAAGTAACAC-CACC-A-GCACCAC-GCTTGGCCTCCGT-CGTCGCTGTGGC 443
 CTCAC GGAAAGT AC C CA A G C C GCT GGC C G C T GC T C
 Sbjct: 877 CTCAC TGGAAAGTGACGCGCATGGACGGGGCCCAGCTAGGCGCCAGGACTTGGCC-T--C 933

5 Query: 442 ACGCTCAGCCTGTGT-GCTC-CGGTCAGC 416
 AC CTC G CTG G GCT CGG C GC
 Sbjct: 934 ACCCTCTGGCTGAGGAGCTGTGG-CTGC 961

Blast-X Results:

>ptnr:SWISSNEW-ACC:P30042 ES1 PROTEIN HOMOLOG, MITOCHONDRIAL PRECURSOR
 (PROTEIN KNP-I) (GT335 PROTEIN) - Homo sapiens (Human), 268 aa.

10 Top Previous Match Next Match
 Length = 268

Minus Strand HSPs:

15 Score = 505 (177.8 bits), Expect = 2.0e-47, P = 2.0e-47
 Identities = 94/104 (90%), Positives = 99/104 (95%), Frame = -1

Query: 797 EFHGAKKPIGLCCIIAPVLAAKVIKGEVTVGHEQEEGGKWPYAGTAEAVKALGAKHCVK 618
 EFH A KPIGLCCIIAPVLAAKV++GVEVTVGHEQEEGGKWPYAGTAEA+KALGAKHCVK
 20 Sbjct: 165 EFHQAGKPIGLCCIIAPVLAAKVLRGVEVTVGHEQEEGGKWPYAGTAEAIKALGAKHCVKE 224

Query: 617 VTEAHVDQKNKVVTTPAFMCETELHHIHDGIGAMVKKVLELTGK 486
 V EAHVDQKNKVVTTPAFMCET LH+IHDGIGAMV+KVLELTGK
 Sbjct: 225 VVEAHVDQKNKVVTTPAFMCETALHYIHDGIGAMVRKVLELTGK 268

25 Principle components analysis was used to generate three eigenvectors used to transform the original expression level data matrix, as shown in Table 4 below. Eigenvector 1 values represent NSAIDs with low risk of hepatotoxicity, Eigenvector 2 values represent NSAIDs with very low risk of hepatotoxicity, and Eigenvector 3 values represent NSAIDs with overdose risk of hepatotoxicity.

30 Table 4: Transform Eigenvectors for Hepatotoxicity Markers by Risk Classification

Gene	Eigenvector 1	Eigenvector 2	Eigenvector3
RISKMARKER1	26.9	6.7	-0.9
RISKMARKER2	23.3	-1.4	1.5
RISKMARKER3	-26.0	-1.5	-2.3
RISKMARKER4	12.6	-2.2	-6.4
RISKMARKER5	18.0	-1.3	-3.1
RISKMARKER6	-13.8	4.71	19.3
RISKMARKER7	-29.7	-7.5	1.3
RISKMARKER8	19.3	1.2	-2.6
% of variation explained	99.6	0.4	0.1

These eigenvectors may be used to transform the expression levels of RISKMARKERS 1-8 ("RISKMARKERS") in response to a given drug, in order to determine that drug's hepatotoxicity risk. For example, expression levels of RISKMARKERS correlating with

Eigenvector 1 indicates that the test drug has a low risk of hepatotoxicity. Alternatively, a drug's RISKMARKERS expression profile can be generated simultaneously with the above-described training set (or an equivalent set) run in parallel with the test drug, and expression levels associated with the test drug directly compared to those of the training set.

- 5 A second training set based on type of injury (hepatocellular damage, cholestasis, elevated transaminase level) was also constructed, utilizing the compounds indicated in Table 5, below.

Table 5: Training Set of NSAIDs by Injury Type

Control	Hepatocellular	Cholestasis	Elevated transmainases
Sterile water	Acetaminophen	Benoxaprofen	Zomepirac
10% ethanol	Flurbiprofen	Nabumetone	Mefenamic acid
Canola oil	Ketoprofen	Sulindac	Tenoxicam

This analysis produced ten fragments that significantly ($p=8.7 \times 10^{-18}$) discriminated among the drugs in the test set. The identities of these ten fragments (INJURYMARKER 1-10) that are included in the discriminatory set (with GenBank accession numbers) are shown below. Where appropriate, the cloned sequence from isolation is provided, and this sequence was then extended using either Genbank rat ESTs or from internally sequenced (Curagen Corporation) rat fragments. The fragments were used to extend the cloned sequence, and the extended contig sequence is provided as "consensus." Finally, the best BlastN and BlastX results are also provided. In some instances the cloned sequence is identical to a known rat gene, in those instances the name of the gene and the GenBank accession number is provided.

INJURYMARKER1

INJURYMARKER1 is a 1025 bp rat express sequence tag (EST) [AI169175]. The nucleic acid was initially identified in a cloned fragment having the following sequence:

```

1   CTGATTTCAAATTTTATTAGAGAACTTTCGGATTTCAAATTTTATTACAGAACAAACATTTTCTGATTTCAAATTT
81  CTATTATAATTCTCCAGTAATCAAAGCAGTGGCGTTGGCATGAAGGCAGACAGAGGTCATGGAAGAGACCAGGCTCAGAA
161 ACAGCCCCACCATGCACAGCGGGATGTTTTCCACCAAGGGCAACATGCAAAGCCAGGTATCCACATGGGTAGAGTAGAA
241 AGTCAGACCTTACATCTCACACACAAATGAACTCAAATATACCAGAGAGCAAAGCTAAGAGCTAAATCAAGTTTCCTA

```

321 GGGCAAGCTGTAGTAGGCTCCCTTGGGTGGGTTAATGCTTTTGTGGATGTGACTACCAAAAATTCAACCAGAGCCAACGA
401 CCCAACTATTAATGGGCAGTGGACCTAAAGAGATTCTTCAAACGATATATAAAGAAGGCCACCAAGCATATAAAACATG
481 TGACATCAGTAGTCAGAGAGATGGGAAGCAGAAGCACTAGCAGATCTTAACACCTACTAGAACANCCACTAAAAAGAGT
561 AAGACTCACAAGGACATGGGCACCTTCTAATCTCTGTGCACTGCTGCCAGGACATACAATAGTGTGGTCACTATGGGAGACT
641 ACGGCAGTGCCTACTAATAACAGCAGAGTTACCCTAAGACATACAATCTGCTGCGTGTATGCTAAGCAGGATCCGAGGGA
TATTTGTATATACATGTTTCACAGCATAGTCAGGAGCTCCAGGGTGGGAACAACCTGAGGTACC
721 (SEQ ID NO: 11)

The cloned sequence was assembled into a contig resulting in the following consensus sequence:

1 CTGATTTCAAATTTTATTATAGAACACTTTCTGATTTCAAATTTTATTACAGAACAACATTTTCTGATTTCAAATTT
81 CTATTATAATTCTCCAGTAATCAAAGCAGTGGCGTTGGCATGAAGGCAGACAGAGGTCTGGAAGAGACCAGGCTCAGAA
161 ACAGCCCCACCATGCACAGCGGGATGTTTTCCACCAAGGGCAACATGCAAAGCCAGGTATCCACATGGGTAGAGTAGAA
241 AGTCAGACCTTACATCTCACACACAAATGAACTCAAATATACCAGAGAGCAAAGCTAAGAGCTAAAATCAAGTTTCCTA
321 GGGCAAGCTGTAGTAGGCTCCCTTGGGTGGGTTAATGCTTTTGTGGATGTGACTACCAAAAATTCAACCAGAGCCAACGA
401 CCCAACTATTAATGGGCAGTGGACCTAAAGAGATTCTTCAAACGATATATAAAGAAGGCCACCAAGCATATAAAACATG
481 TGACATCAGTAGTCAGAGAGATGGGAAGCAGAAGCACTAGCAGATCTTAACACCTACTAGAACAGCCACTAAAAAGAGT
561 AAGACTCACAAGGACATGGGCACCTTCTAATCTCTGTGCACTGCTGCCAGGACATACAATAGTGTGGTCACTATGGGAGACT
641 ACGGCAGTGCCTACTAATAACAGCAGAGTTACCCTAAGACATACAATCTGCTGCGTGTATGCTAAGCAGGATCCGAGGGA
721 TATTTGTATATACATGTTTCACAGCATAGTCAGGAGCTCCAGGGTGGGAACAACCTGAGGTACCCACGGCTGGATGAGTAGG
801 TAACAAGAAACATACAGCATACATACAACACACACTAAAGTCTAAAGTACTATTTGTCTTACAAGGAAACTCATACAT
881 GATACAAGCCTTCACGGCATTCTGTACATGAACACGCACACACACACACACACACACACACACGCACTGAGAATC
TATGTATACCAGGCACTTAGGGTACTCAAATTCAGAAACAGGACAGAGAATGGTGATTGCCATGG
961 (SEQ ID NO: 12)

5 **Blast-N Results:**

>gb:GENBANK-ID:AI169175|acc:AI169175 EST215009 Normalized rat kidney, Bento Soares Rattus sp. CDNA clone RKIBO44 3' end, mRNA sequence - Rattus sp., 670 bp (RNA).

Top Previous Match Next Match
Length = 670

Plus Strand HSPs:

Score = 3305 (495.9 bits), Expect = 4.3e-143, P = 4.3e-143
Identities = 661/661 (100%), Positives = 661/661 (100%), Strand = Plus / Plus

Query: 4 ATTTCAAATTTTATTATAGAACACTTTCTGATTTCAAATTTTATTACAGAACAACAT 63
|||||
Sbjct: 1 ATTTCAAATTTTATTATAGAACACTTTCTGATTTCAAATTTTATTACAGAACAACAT 60
Query: 64 TTTCTGATTTCAAATTTCTATTATAATTCTCCAGTAATCAAAGCAGTGGCGTTGGCATGA 123
|||||

Sbjct: 61 TTTCTGATTTCAAATTTCTATTATAATTCTCCAGTAATCAAAGCAGTGGCGTTGGCATGA 120

Query: 124 AGGCAGACAGAGGTCATGGAAGAGACCAGGCTCAGAAACAGCCCCACCATGCACAGCGGG 183

5 Sbjct: 121 AGGCAGACAGAGGTCATGGAAGAGACCAGGCTCAGAAACAGCCCCACCATGCACAGCGGG 180

Query: 184 ATGTTTTCACCAAGGGCAACATGCAAAGCCAGGTATCCACATGGGTAGAGTAGAAAGT 243

10 Sbjct: 181 ATGTTTTCACCAAGGGCAACATGCAAAGCCAGGTATCCACATGGGTAGAGTAGAAAGT 240

Query: 244 CAGACCTTACATCTCACACACAAATGAACTCAAAATATACCAGAGAGCAAAGCTAAGAGC 303

Sbjct: 241 CAGACCTTACATCTCACACACAAATGAACTCAAAATATACCAGAGAGCAAAGCTAAGAGC 300

15 Query: 304 TAAAATCAAGTTTCCTAGGGCAAGCTGTAGTAGGCTCCCTTGGGTGGGTTAATGCTTTTG 363

Sbjct: 301 TAAAATCAAGTTTCCTAGGGCAAGCTGTAGTAGGCTCCCTTGGGTGGGTTAATGCTTTTG 360

20 Query: 364 TGGATGTGACTACCAAAAATTCAACCAGAGCCAACGACCCAATTAATGGGCAGTGGA 423

Sbjct: 361 TGGATGTGACTACCAAAAATTCAACCAGAGCCAACGACCCAATTAATGGGCAGTGGA 420

Query: 424 CCTAAAGAGATTTCTTCAAACGATATATAAAGAAGGCCACCAAGCATATAAAACATGTGA 483

25 Sbjct: 421 CCTAAAGAGATTTCTTCAAACGATATATAAAGAAGGCCACCAAGCATATAAAACATGTGA 480

Query: 484 CATCAGTAGTCAGAGAGATGGGAAGCAGAAGCACTAGCAGATCTTAACACCTACTAGAAC 543

30 Sbjct: 481 CATCAGTAGTCAGAGAGATGGGAAGCAGAAGCACTAGCAGATCTTAACACCTACTAGAAC 540

Query: 544 AGCCACTAAAAAAGAGTAAGACTCACAAGGACATGGGCACCTTCTAATCTCTGTGCACTGC 603

Sbjct: 541 AGCCACTAAAAAAGAGTAAGACTCACAAGGACATGGGCACCTTCTAATCTCTGTGCACTGC 600

35 Query: 604 TGCCAGGACATACAATAGTGTGGTCACTATGGAGACTACGGCAGTGCCTACTAATAACAG 663

Sbjct: 601 TGCCAGGACATACAATAGTGTGGTCACTATGGAGACTACGGCAGTGCCTACTAATAACAG 660

40 Query: 664 C 664

Sbjct: 661 C 661

INJURYMARKER2

INJURYMARKER2 is a 893 nucleotide sequence encoding phosphotidylethanolamine N-methyltransferase [L14441]:

45 1 tccccgctga gttcatcacc agggacaggt gacctgagct gccctggag cccagctccc

61 atttccttct ggttctggcc gatctcttcg ttatgagctg gctgctgggt tacgtggacc

121 ccacagagcc cagctttgtg gcggtgtgct tcaccattgt gttcaatcca ctcttctgga

181 atgtggtagc aaggtgggag cagagaactc gcaagctgag cagagccttc ggggtcccctt

241 acctagcctg ctattccctg ggcagcatca tctgtcttct gaacatcctc cgtcccact

50 301 gcttcacaca ggccatgatg agccagccca agatggaggg cctggatagc cacaccatct

361 acttctctggg ccttgcactc ctgggctggg gactcgtgtt tgtgctctcc agcttctatg

421 cactgggggt cactgggacc tttctaggtg actacttttg gatcctcaag gagtccagag

481 tgaccacatt tcccttcagc gtgctggaca acccatgta ctggggaagt acagccaact

541 acctaggctg ggcacttatg cagccagcc ctacaggcct gctgttgacg gtgctggtgg

55 601 cactcgtcta cgtggttget ctctgtttg aagagccctt cactgaggag atctaccggc

661 ggaaagccac caggttgac aaaggagct gacagggcca tgagggacct ttggaaagcc

721 ggattgcctc ccggtgacc caagcaacaa cccttctcgg ggagagcagc gctggccatt

781 gtacctgtgc cttggaaacc agtcatgggg gtgctcaggc attatgtcat gtgactgctg

841 agaccccat cccaccaat ccctgacaca ctaataaagg ctttgtgacc tcc

INJURYMARKER3

INJURYMARKER3 is a 1131 nucleotide hexokinase-encoding sequence [M86235]:

```

5   1   agcaggaatc ccctccgctt gcgggtagga agcttgggga gcagcctcat ggaagagaag
61  cagatcctgt gcgtggggct ggtggtgctg gacatcatca atgtggtgga caaataccca
121 gaggaagaca cggatcgagc gtgcctatcc cagagatggc agcgtggagg caacgcgtcc
181 aactcctgca ctgtgctttc cttgctcgga gcccgctgtg ccttcatggg ctcgctggcc
241 catggccatg ttgccgactt cctgggtggc gacttcaggc ggaggggtgt ggatgtgtct
10  301 caagtggcct ggcagagcca gggagatacc ccttgctcct gctgcatcgt caacaactcc
361 aatggctccc gtaccattat tctctacgac acgaacctgc cagatgtgtc tgctaaggac
421 tttgagaagg tcgatctgac ccggttcaag tggatccaca ttgagggccg gaatgcatcg
481 gaacaggtaa agatgctaca gcggatagaa cagtacaatg ccacgcagcc tctgcagcag
541 aaggtccggg tgtccgtgga gatagagaag ccccgagagg aactcttcca gctgttcggc
15  601 tatggagagg tgggtgtttgt cagcaaagat gtggccaagc acctgggggt ccggtcagca
661 ggggaggccc tgaagggtt gtacagtcgt gtgaagaaag gggctacgct catctgtgcc
721 tgggctgagg agggagccga tgccctgggc cccgacggcc agctgctcca ctcagatgcc
781 tccccaccac cccgagtagt agacactctc ggggctggag acaccttcaa tgccctgttc
841 atcttcaagg tctccaaggg aaacagcatg caggaggccc tgagattcgg gtgccagggtg
20  901 gctggcaaga agtgtggctt gcaggggttt gatggcattg tgtgagagat gagcgggtggg
961 aggtagcagc tcgacacctc agaggctggc accactgcct gccattgcct tcttcatttc
1021 atccagcctg gcgtctggct gccagttcc ctgggccagt gtaggctgtg gaacgggtct
1081 ttctgtctct tctctgcaga cacctggagc aaataaatct tcccctgagc c

```

INJURYMARKER4

INJURYMARKER4 is a 1994 nucleotide sequence encoding mitochondrial HMG-CoA Synthase [M33648]:

```

1   atctctccca ggggctgtgg actgctggct ttctgttgat accttagaga tgcagcggct
61  tttggctcca gcaaggcggg tcctgcaagt gaagagagtc atgcaggaat ctctgctctc
30  121 acccgctcac ctgctccccg cagcccagca gaggttttct acaatccctc ctgctccccct
181 ggccaaaact gatacatggc caaaagatgt gggcatcctt gccctggagg tctactttcc
241 agcccaatat gtggacaaa ctgacctgga gaagttcaac aatgtggaag cagggaagta
301 cacagtgggc ttgggcccaga cccgtatggg cttctgttcg gtccaggagg acatcaactc
361 cttgtgcctc acagtgggtg agaggctgat ggaacgcaca aagctgccat gggatgccgt
35  421 aggcgcctg gaagtgggca cggaaacct cattgacaag tccaaggctg tcaagacagt
481 gctcatggag ctcttccagg attcaggcaa cactgacatc gagggcatag ataccaccaa
541 cgctgctat ggtggcactg cctccctctt caacgctgcc aactggatgg agtccagcta
601 ctgggatggg cgctatgccc tgggtggtctg tggtgatata gcagtctacc caagtggtaa
661 ccccgcccc acaggtgggtg ccggggctgt ggcaatgctg attgggcccc aggccccgct
40  721 agtcctggaa caagggtgga ggggaacca catggagAAC gcctatgact tctacaaacc
781 aaacttggcc tcagagtatc cactggtgga tgggaagctg tctatccagt gctacctgcy
841 ggcttggac cgatgctatg cagcttaccg caggaaaatc cagaatcagt ggaagcaagc
901 tggaaacaac cagcctttca ccctcgatga cgtgcaatat atgatcttcc acacaccctt
961 ttgcaagatg gtccagaaat ccctagctcg gctgatgttc aatgacttcc tgtcatctag
45  1021 cagtgacaag cagaacaact tatacaaggg tctagaggcc ttcaagggtc taaagctgga
1081 agaaacctac accaacaagg atgttgacaa ggctctgctg aaggcctccc tggacatgtt
1141 caacaagaaa accaaggcct ccctttacct ctccacaaac aatgggaaca tgtacacctc
1201 gtccctctac ggggtgcctgg cctcacttct ctcccaccac tctgcccagg aattggccgg
1261 ctccaggatt ggagccttct cctacggctc aggcttagca gcaagtttct tctcatttcg

```

09717321-112000

10

INJURYMARKER5

15

45

INJURYMARKER6

INJURYMARKER6 is a 993 nucleotide sequence encoding hydroxysteroid
sulfotransferase [D14989]:

1	ggcaagggct	ggaataactaa	aagttattca	tgatgtcaga	ctatacttgg	tttgaaggaa
5	61	taccttttcc	tgcccttttg	ttttccaaag	aaattctgga	aaatagttgt
	121	tggtaaaaga	agacgacttg	atcatattga	cttaccocaa	gtcaggaacg
	181	tcgagattgt	ctgcttgatt	cagaccaagg	gagatcccaa	gtggatccaa
	241	tctgggatcg	ctcaccctgg	atagagactg	gttcaggata	tgataaatta
	301	aaggaccacg	actcatgacc	tcccatcttc	ccatgcatct	tttctccaag
10	361	gttccaaggc	caaggtgata	tatctcatca	gaaatcccag	agatgttctt
	421	atTTTTtctg	gagtaagatc	gccctggaga	agaaaccaga	ctcgctggga
	481	aatggttcc	caaaggaaat	gttgcataatg	gatcatggtt	tgagcacatc
	541	tgtctatgag	agaatgggac	aacttcttgg	tactgtacta	tgaagacatg
	601	caatgggac	cataaagaag	atatgtgact	tcttggggaa	aaaattagag
15	661	tgaatttgg	cctcaagtat	agttccttcc	aagtcgtgaa	agaaaacaac
	721	atagcctcat	ggagaaggaa	ctgattctta	ctggttttac	tttcatgaga
	781	ctagctatg	gaagaatcac	ttcacagtag	cccaagctga	agcctttgat
	841	aggagaaaat	ggccgggttc	cctccaggga	tggtcccatg	ggaataaatt
	901	ttaaatat	tatgaacact	gatgtttatg	tttatgttgt	tctatgatgt
20	961	gaatgtgatc	attgaataaa	tctgtgtgtg	gat	

INJURYMARKER7

INJURYMARKER7 is a 5001 nucleotide sequence encoding insulin-like growth factor
binding protein [L22979]:

25	1	cacaaacceca	gcgagcattg	aacactgcac	acggccatct	gccagagag	ctgtgaccac
	61	cacttccgct	actatctact	cagaaagtcg	tgactactga	gccactgctg	cctgcccaga
	121	ttctcatcca	ccgcctgctg	cgtctgggtg	cgatgccgga	gttccctaact	gttgtttctt
	181	ggcggttcct	gacccctcctg	tccttccagg	ttcgcgtagt	cgctggagcc	ccccagccat
	241	ggcactgtgc	tccttgcact	gctgagaggg	tgagctctg	tccaccctg	cctgcttcgt
30	301	gccccgagat	ttctcgccct	gcgggctgtg	gctgctgccc	gacatgtgcc	ttgccactgg
	361	gtgctgcctg	tggtgtggcc	actgcggcct	gcgctcaggg	actcagctgc	cgtgcgctgc
	421	caggggagcc	tcgacctctg	catgccctca	ccggtggcca	gggagcctgt	gtactagaac
	481	ctgccgcacc	cgccacgagc	agcttgtccg	gttctcagca	tgaaggtagt	acagccctct
	541	ctgcctcttg	atctcttggc	taggacacac	gtgctttcta	ggcacgtcag	aggcctatcc
35	601	ggaacctata	gcagatagga	caaaggctct	ccatgcccac	tttgagcttt	cagcctcaaa
	661	taaggccctc	agttaggtag	tgggcggttg	ggaaacacca	gaggtgtcaa	tccagtagca
	721	gagtgagaga	gttgggaaga	atgttccaag	ctcccagtag	agagtggaga	gttgggaaga
	781	atgttcacag	actaggtagt	actgacccctg	cttgggtctt	cagtggggag	ggagctatgg
	841	ggctgccagg	tggttggggg	gctggcccaa	acacctctt	ctgtgggtcc	tgaccttggc
40	901	agttccaatg	gctaaaagg	ccaggaagg	ttaggatggg	agccctcctg	ctgccccag
	961	gaggtttgca	atgtcctttg	tagcatatat	cctgccacac	agtatgtgct	tcccagatgt
	1021	ttacagaaca	taatgtgaaa	atthagggcc	aaaccttcac	ttccattcat	tgctatagac
	1081	aaacagtgtt	tgaagtgtat	gttgccctg	aggagtctga	caatcaggcg	ctttcctgaa
	1141	tttaagcact	ggtttgtttg	taataggaag	cttgggaaat	gcctcttcct	ctgctccagc
45	1201	ccctatctcc	cctgtctggg	ctgcatgcac	ttcctgtgtg	ggtaaggag	ctcatggttc
	1261	catattctga	cggaagccg	gactgcaggc	atctgatcct	tttgactaaa	tggaagaact

5	1321	atcccaacg	tccttagaaa	cgggcttccc	caggagcgat	gtctgataat	gtcctcctct
	1381	gtgaggggct	gcctaagagg	tgtcgggtgtt	caagaaagca	gggctcccag	aaaagaagag
	1441	gatgggtggtg	tgaggtgggg	aaggctacac	tctacacctt	gcttctcaac	tatcccccta
	1501	ctgggggtctt	acgagattct	ttttgtgggtg	tggagaggag	agctgagtgg	tcaagtctca
	1561	ccactaacg	gttcaagcct	tggcctcagt	ccttggcttc	ttcaggatta	catcctagac
10	1621	ccaactctct	ctgccatggg	gactcccttg	cctaacccca	aaacatacca	tttccccaga
	1681	aaggaattag	tattgtcta	tgggtgataat	tgttcccaaa	tagcccaactg	gtgaaaacaa
	1741	agcctgattt	cacctgactg	ttacagattg	gtcttaaggc	ggtagacgtg	agtgacatag
	1801	gagtgcaccc	tcagggctca	tcgtctgtgt	ctgtgggggtt	cgttttcaga	ggcaaaggct
	1861	gctgtggcct	ctgaggatga	gcttgccgag	agcccagaga	tgacagagga	acagctgctg
15	1921	gatagcttcc	acctcatggc	ccatcccg	gaggaccagc	ccatcctgtg	gaatgccatt
	1981	agcacctaca	gcagcatgcg	ggcccgggag	atcactgacc	tcaagaaatg	gaaggtgaga
	2041	ccctgcactc	agaccttcag	gtttagctat	ctacgtgaag	aggtttgtct	agacgatttc
	2101	ttaaagggca	ctgagcatgg	ggctgagaac	gggatataa	ctacccccat	ccctgatgta
	2161	tttctgcctc	cttaaaaata	tggcaagtat	ctcagagcat	aaggtagggc	atttttcagt
20	2221	ctaggtttct	ctgtcaccca	gtacgcacgt	tcagtgattg	ttagccacca	accagctcca
	2281	cggttttgcc	agccttttagc	tatgcacttt	agctatgcag	taaacttctc	tagctttact
	2341	ggctgttttt	caacttgacc	acttggggga	gacagagaac	caaaggtgga	gagaaagtac
	2401	ggcagaggca	ttgaagaagt	acacctaaag	aatgaaagg	ataaacattg	ttaggggcac
	2461	tttagaattt	catatggaaa	ttgtccaaat	cagtgccttg	ttccgtaatc	aatttgacat
25	2521	acaccaaagt	caaggatggc	tgtttgaaaa	atctaggcat	ttatgatgct	aaattccaca
	2581	cacagagact	gagcctgtct	tttttattag	agttcagggtg	ctcaagttat	tcagagatag
	2641	ccagggtcag	gaagcattta	taccattggc	caggctctta	ccacaatgtc	gttaaggggg
	2701	tctccagaaa	atgccactga	gggaggatga	gagtgggtgc	cctgtccttt	atctacatag
	2761	cccaagccag	agaccaacct	gtcctgtctca	cagatgggga	aacatctcag	ccgttgtcta
30	2821	aattgataat	ttttgtctct	tgtactcatg	ctaataataa	attatccttt	taggagccct
	2881	gccaacggga	actctataaa	gtgttagaga	gattagctgc	cgctcaacag	aaagcaggag
	2941	atgagatcta	caaattttat	ctgccaaact	gcaacaagaa	tggattttat	cacagcaaac
	3001	aggtaggtgg	ctttgtctcat	ccagatcctt	gtaaaacttc	atgatttttt	tttttaaagt
	3061	caaagtattc	acaggcccaa	tacacatcat	gggtagcttt	cttaggtgag	atccagccct
35	3121	gcagtagttg	ggagaagcta	gtcctgagaa	agagatagtg	tgatggatga	ggaacacttc
	3181	agccagaagg	gaggactaag	cattagtgtg	atgagtgagg	agcacttcag	ttaacaggga
	3241	ggactaagca	ttagtgtgat	gagtgaggac	cacttcaagc	cagagggagg	actaacattg
	3301	gcagtatgat	gagtgaggag	cacttcagcc	agtagggagg	actaaccatt	agtctcatca
	3361	ctaggagcac	ctcagccaag	tagggaggac	taaccattag	tctcacactc	acccaacatc
40	3421	ttcagtcagg	actaagcatt	agtgtgatga	gtgaggagca	cttcagtcag	tagggaggac
	3481	tacattagt	tgatgagtga	ggagcacttc	agccagtagg	gaggactaac	cgttcactca
	3541	gattagcaga	gatggatgtt	ccatatactg	atgtccaggt	ttcagttcct	cacaactaga
	3601	ggaaagggac	acagtcagtg	taggagacag	atgtctcgcg	ttctctcttc	ccacaaataa
	3661	aaacaaactc	tgtagtaaga	cacaccaatt	gtgctttgcc	tgcataataa	tgagattgaa
45	3721	gaagtcagg	cttaatttcg	acgcaacttt	agaactcagg	gaagtgcaag	ttctggaatt
	3781	tcattgagga	aaaacttgag	gtctaggtct	agccgtgtgg	tagagatgg	gagacctatc
	3841	gttgagctcc	tttggcagag	ggccatggag	caggtaaccg	tcaaaacaat	ataccactga
	3901	gtaaacagat	gagattgtta	tcaggtgtgc	cataaagcca	acctctccgt	tttgtgatga
	3961	caaccagaag	ggcattgggtc	tgccgagcct	tagccagcag	gtagctgtgc	agtgtttggc
50	4021	ctcactgagg	gacaggggtg	ccagagctct	tacctctgc	tgctcttgac	ctcggtcctg
	4081	tctttgcagt	gcgagacatc	tctggatgga	gaagctgggc	tctgctgggtg	tgtctacca
	4141	tggagtggga	agaagatccc	tggatctctg	gagaccagag	gggaccccaa	ctgccaccag
	4201	tatttttaatg	tgcaaaactg	aaagttgttt	cctccctcct	tcttcacaca	aaatatttaa
	4261	gtatatagt	tattttatact	ccggagcaca	ccattttata	tatgtgtata	tgtatatatc
55	4321	caggaactag	ttttttatact	ccacatgctg	cttgatgtac	aagtgggttt	gtattttattc
	4381	actctaagtt	tattttttttc	tacctgtctc	ttgtgctgta	ttaattttata	taactgaagc
	4441	ttttctcatc	tccatacatg	taaatactac	catctcagct	cttcagagat	tctgctttga
	4501	aagggcagcg	cggtagcgtgc	ctagaacgag	cacaagtcag	tctgaggtag	gggcctttca
	4561	gtgggttcag	ggaggaaggt	tagccctggc	tcggggagac	ttcctcatcg	aatcccacag
60	4621	gtctgtgtct	gtaggcattt	ggctgggaag	gttccgatgt	tggttgtgta	atcaaagcta
	46						

4741 tggaacact gctgtctctg tggaattcca gctctgtgct cattccctca gtccgttcgg
4801 ctttcccgt cgcctgattc ctgggtctgt gctttgggga tagatgttgc aatacagggg
4861 gcttgtttgt ttacagaaca ccctggacaa acactctgtg actttatggg cccattttca
4921 agcagcatca ggcctctgtc tgggccagac tacagagccc ctctctcttg gtccatctcc
5 4981 ctttcttccc agggccctca g

INJURYMARKER8

INJURYMARKER8 is 579 bp rat expressed sequence tag (EST) [AA851963]. The nucleic acid was initially identified in a cloned fragment having the following sequence:

1 TGTACATAATTTATTAAAAATGTCTCTGACACAAATAATGACTCCACTGCATACATAGTTGGTGTTCAAAAATTTCCCCA
81 ATGTTTGTCTCTGGACACAATGTTATTAGCCAACCTCGGTGAATTCAAGACATTGTTCCACACAATGAACAATCGCACACA
161 TGAGAACTGCACCTAGAATGTCCATCCTAGAAATCTCCATCCATCCAGTCAAAGTGCTGAGCTCACTGACTGAAGGAAACA
241 TGACCTGTGTCTAGA (SEQ ID NO: 13)

The cloned sequence was assembled into a contig resulting in the following consensus sequence:

1 TGTACATAATTTATTAAAAATGTCTCTGACACAAATAATGACTCCACTGCATACATAGTTGGTGTTCAAAAATTTCCCCA
81 ATGTTTGTCTCTGGACACAATGTTATAAGCCAACCTCGGTGAATTCAAGACATTGTTCCACACAATGAACAATCGCACACA
161 TGAGAACTGCACCTAGAATGTCCATCCTAGAAATCTCCATCCATCCAGTCAAAGTGCTGAGCTCACTGACTGAAGGAAACA
241 TGACCTGTGTCTAGAACGTAGCTGGCTATGAAGTTTACTCATGTGTAAATTCCTTAAAAAGATTAAATGTTTGGCCCCA
321 TTTCTATATTTCAAAAATAACTATAATTACAACTTTCTAAAAATAATTTTACAACCATGTAATTATGACTAACCATAT
401 CATCTAAAAAGTAAGTGAAGTCATTGTCCTAGAGATTGTCTGAGATTATTCTGCTGAGAAGCTTACTTCAAACCTTATC
481 ACTACTTCCTACTTCCAGTGTCTTGAATTAAGAACAGAAATTGTAAGTATGCTATTCTACATCAGATTGACACAACCTA
561 CTTCTAAGTACACTATTGC (SEQ ID NO: 14)

Blast-N Results:

>gb:GENBANK-ID:AA851963|acc:AA851963 EST194732 Normalized rat spleen, Bento Soares
Rattus sp. cDNA clone RSPA086 3' end, mRNA sequence - Rattus sp., 538 bp (RNA).

Top Previous Match Next Match
Length = 538

Plus Strand HSPs:

Score = 2681 (402.3 bits), Expect = 8.1e-115, P = 8.1e-115
Identities = 537/538 (99%), Positives = 537/538 (99%), Strand = Plus / Plus

Query: 42 CTCCACTGCATACATAGTTGGTGTTCAAAAATTTCCCAATGTTTGTCTGGACACAATT 101
 Sbjct: 1 CTCCACTGCATACATAGTTGGTGTTCAAAAATTTCCCAATGTTTGTCTGGACACAATT 60

5 Query: 102 GTTATAAGCCAACTCGGTGAATTCAAGACATTGTTCCACACAATGAACAATCGCACACAT 161
 Sbjct: 61 GTTATAGCCAACTCGGTGAATTCAAGACATTGTTCCACACAATGAACAATCGCACACAT 120

10 Query: 162 GAGAACTGCACCTAGAATGTCCATCCTAGAATCTCCATCCATCCAGTCAAAGTGCTGAGC 221
 Sbjct: 121 GAGAACTGCACCTAGAATGTCCATCCTAGAATCTCCATCCATCCAGTCAAAGTGCTGAGC 180

15 Query: 222 TCACTGACTGAAGGAAACATGACCTGTGTTCTAGAACGTAGCTGGCTATGAAGTTTACTC 281
 Sbjct: 181 TCACTGACTGAAGGAAACATGACCTGTGTTCTAGAACGTAGCTGGCTATGAAGTTTACTC 240

20 Query: 282 ATGTGTAATTCCTTAAAAAGATTAAATTGTTGGCCATTCTATATTTCAATAAATAA 341
 Sbjct: 241 ATGTGTAAATTCCTTAAAAAGATTAAATTGTTGGCCATTCTATATTTCAATAAATAA 300

25 Query: 342 CTATAATTACAACTTTCTAAAAATAATTTTACAACCATGTAATTATGACTAACCATATC 401
 Sbjct: 301 CTATAATTACAACTTTCTAAAAATAATTTTACAACCATGTAATTATGACTAACCATATC 360

30 Query: 402 ATCTAAAAAGTAAGTGAAGTCATTGTCTAGAGATTGTCTGAGATTATTCTGCTGAGAAG 461
 Sbjct: 361 ATCTAAAAAGTAAGTGAAGTCATTGTCTAGAGATTGTCTGAGATTATTCTGCTGAGAAG 420

35 Query: 462 CTTACTTCAAACCTCTTACTACTTCCAGTGTCTTGAATTAAGAACAGAAA 521
 Sbjct: 421 CTTACTTCAAACCTCTTACTACTTCCAGTGTCTTGAATTAAGAACAGAAA 480

Query: 522 TTGTAACATATGCTATTCTACATCAGATTGACACAACCTACTTCTAAGTACACTATTGC 579
 Sbjct: 481 TTGTAACATATGCTATTCTACATCAGATTGACACAACCTACTTCTAAGTACACTATTGC 538

INJURYMARKER9

INJURYMARKER9 is a 2495 nucleotide catalse-encoding sequence[M11670], having the following nucleic acid sequence:

40 1 attgcctacc ccgggtggag accgtgctcg tccggccctc ttgcctcagc ttctgcagct
 61 ctgcagctcc gcaatcctac accatggcgg acagccggga cccagccagc gaccagatga
 121 agcagtggaa ggagcagcgg gcccctcaga aaccgatgt cctgaccacc ggaggcggga
 181 acccaatagg agataaactt aatatcatga ctgcggggcc ccgagggccc ctctcgcttc
 241 aagatgtggt ttccaccgac gagatggcac actttgacag agagcggatt cctgagagag
 45 301 tggtagatgc aaaggggagca ggtgcttttg gatactttga ggtcaccac gatattacca
 361 gatactccaa ggcaaagggtg tttgagcata ttgggaagag gactcctatt gccgtccgat
 421 tctccacagt cgctggagag tcaggctcag ctgacacagt tcgtgaccct cgtggggttg
 481 cagtgaatt ctacactgaa gatggtaact gggacctcgt gggaaacaac acccctattt
 541 tcttcatcag ggatgccatg ttgtttccat cctttatcca tagccagaag agaaaccac
 50 601 aaactcacct gaaggacct gacatggtct gggacttctg gagtctttgt ccagagtctc
 661 tccatcaggt tactttcttg ttcagcgacc gagggattcc agatggacat cggcacatga
 721 atggctatgg ctcacacacc ttcaagctgg ttaatgcgaa tggagaggca gtgtactgca
 781 agttccatta caagactgac cagggcatca aaaacttgcc tgttgaagag gcaggaagac
 841 ttgcacagga agaccggat tatggcctcc gagatctttt caatgccatc gccagtggca
 55 901 attaccatc ctggactttt tacatccagg tcatgacttt caaggaggca gaaaccttcc
 961 catttaatcc atttgacctg accaagggtt ggccctcaca ggactaccct cttataaccag
 1021 ttggcaact ggtcttaaac agaaatcctg ctaattattt tgctgaagtt gaacagatgg
 1081 cttttgacct aagcaacatg cccctggca ttgagcccag cccggacaag atgctccagg
 1141 gccgcctttt tgcttaccac gacactcacc gccaccgct gggaccaaac tatctgcaga

```

1201  tacctgtgaa ctgtccctac cgtgctcgcg tggccaacta ccagcgcgat ggccccatgt
1261  gcatgcatga caaccagggg ggtgctccca actactacce caacagcttc agcgcaccag
1321  agcagcaggg ctcgccctcg gagcaccata gccagtgtct tgcagatgtg aagcgcttca
1381  acagtgtctaa tgaagacaac gtcactcagg tgcggacatt ctatacgaag gtgttgaatg
5  1441  aggaggagag gaaacgcctg tgtgagaaca ttgccaaaca cctgaaagat gctcagcttt
1501  tcattcagag gaaagcggtc aagaatttca ctgacgtcca cctgactac ggggcccagag
1561  tccaggctct tctggaccag tacaactccc agaagcctaa gaatgcaatt cacacctacg
1621  tacaggccgg ctctcacata gctgccaaagg gaaaagctaa cctgtaaagc acgggtgctc
1681  agcctcctca gcctgcactg aggagatccc tcatgaagca gggcacaagc ctcaccagta
10 1741  atcatcgctg gatggagtct cccctgctga agcgcagact cacgtgacg tctttaaaac
1801  gataatccaa gcttctagag tgaatgatag ccatgctttt gatgacattt cccgaggggg
1861  aaattaaaga ttagggttta gcaatcactt aacagaaaca tggatctgct taggacttct
1921  gtttggatta ttcatTTaaa atgattacaa gaaaggTTTT ctagccagaa acatgatttg
1981  attagatatg atatatgata aaatcttggg gatTTTacta tagtcttatg ttacctcaca
15 2041  gcctggtata tatacaaac acacacacac acacacacac acacacaaa acacacatac
2101  actatacaca cacacacaca cacacactaa aacacacata cacaacacac acatacacta
2161  cacacacaga acacacaaca caaacatata cacataggca cacacacaca cacacacaca
2221  cacacacaca cacacacaca cacacatgaa tgaagggatt ataaagatgg cccaccaga
2281  atTTTTTTTT atTTTTctaa ggtccttata agaaaaacca tacttggaac atgtcttcca
20 2341  aaaataactt tagcactgtt gaaacttaat gtttattcct gtgtagttga ttggattcct
2401  tttccccttg aaattatgtt tatgctgata cacagtgatt tcacataggg tgatttgtat
2461  ttgcttacat ttttacaata aaatgatctt catgg

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INJURYMARKER10

INJURYMARKER10 is a 1884 nucleotide betaine homocysteine methyl transferase-encoding sequence [AF038870]:

```

1  caagcctttg ctggagaccg ctctgttcca gtccgcagct ggcttcagcg ccactcagga
61  caccggaag atggcaccga ttgccggcaa gaaggccaag aggggaatct tagaacgctt
121  aaatgctggc gaagtctgta tccgagatgg gggatttgtc ttgactgctg aaaagagggg
30 181  ctacgtaaag gctggaccct ggacccaga ggcgtcgggt gagcaccctg aggcagttcg
241  gcagcttcat cgggagttcc tcagagctgg atcgaacgtc atgcagacct tcactttcta
301  tgcaagtgag gacaagctgg aaaaccgagg gaactacgtg gcagagaaga tatctgggca
361  gaaggtcaat gaagctgctt gtgacattgc acggcaagtt gctgacgaag gggatgcatt
421  ggttgcagga ggtgtgagtc agacaccttc ctacctcagc tgcaagagtg agacggaagt
35 481  taaaaagata tttaccaaac agcttgaggt cttcatgaag aagaatgtgg acttctctcat
541  tgcagagtat tttgaacatg ttgaagaagc cgtgtgggca gtcgaggcct taaaaacatc
601  cggaagcct atagcggcta ccatgtgcat cggacctgaa ggagatctac atggcgtgtc
661  tcctggagag tgcgcagtgc gtttggtaaa agcaggtgcc gccattgtcg gtgtgaactg
721  ccacttcgac cccagcacca gcttgcagac aataaagctc atgaaggagg gtctggaagc
40 781  agctcggctg aaggcttact tgatgagcca cgccctggcc taccacacce ctgactgtgg
841  caaacaggga tttattgatc tcccagaatt cccctttgga ttggaacca gagttgccac
901  cagatgggat attcaaaaat acgccagaga ggcctacaac ctgggggtca ggtacattgg
961  cggctgctgc ggatttgagc cctaccacat cagggccatt gcagaggagc tcgcccaga
1021  aaggggattt ttaccaccag cttcagaaaa acatggcagc tggggaagtg gtttggacat
45 1081  gcacacaaa ccctggatca gggcaagggc caggaaagaa tactggcaga atcttcgaat
1141  agcttcgggc agaccgtaca atccttcgat gtccaagccg gatgcttggg gagtgcgaa
1201  aggggcagca gagctgatgc agcagaagga agccaccact gagcagcagc tgagagcgct
1261  cttcgaaaaa caaaaattca aatccgcaca gtagccacag gccagcggtt cggggcgaaat
1321  tcctccaggt ccgggccaca gtgtgcaccc ggaaggagaa ggcattctta aaccagcgtt

```

```

1381  tgtgttgatg  ccggcttaca  cctgtgattg  gtgctagtta  gacaaaatgg  agtcacagat
1441  agcatttcac  agttacaaaa  ctacgcttta  gaattttacc  tagaaggaag  aaaggagaag
1501  tccacagtaa  atcctgaaca  catttcctac  gtgcctgtcg  cattacaggc  gcacaggagt
1561  cactgcagcg  aagagaaagt  caccgcacgt  caatctcatt  tcagataggg  ggataggaca
5  1621  ccacctccac  gagtgacata  gaaccattca  gggaccgtat  cataagtgac  acagcaacca
1681  tctatatcta  agatgcttcc  caagtggatt  ccaagatctt  ttgagcagga  cccttaggca
1741  gaaacaacac  acaccagccc  tgtaaaactt  aacagataac  tgatccattc  tgtaattctg
1801  taatctctgt  tctgactgct  tccattccat  ttcattaata  aaaacatgcc  ggttgaaaac
1861  cttcaaaaaa  aaaaaaaaaa  aaaa

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Principle components analysis was used to generate three eigenvectors used to transform the original expression level data matrix, as shown in Table 6 below. Eigenvector 1 values represent NSAIDs associated with hepatotoxicity involving hepatocellular damage, Eigenvector 2 values represent NSAIDs associated with hepatotoxicity involving cholestasis, and Eigenvector 3 values represent NSAIDs associated with hepatotoxicity involving elevated transaminase level.

Table 6: Transform Eigenvectors for Hepatotoxicity by Injury Type

Gene	Eigenvector 1	Eigenvector 2	Eigenvector3
INJURYMARKER1	58.7	0.325	-15.2
INJURYMARKER2	20.5	-3.23	3.01
INJURYMARKER3	-16.9	-6.52	-2.09
INJURYMARKER4	-10.3	0.351	-1.45
INJURYMARKER5	-7.59	-0.152	-0.310
INJURYMARKER6	11.4	-2.69	2.49
INJURYMARKER7	-16.0	-1.57	8.71
INJURYMARKER8	-11.6	1.13	5.36
INJURYMARKER9	-11.0	-0.351	0.078
INJURYMARKER10	7.55	0.618	4.65
% of variation explained	99.0	0.7	0.3

These eigenvectors may be used to transform the expression levels of INJURYMARKERS 1-10 (“INJURYMARKERS”) in response to a given drug, in order to predict that drug’s hepatotoxicity injury type. For example, expression levels of INJURYMARKERS correlating with Eigenvector 1 indicates that the test drug has a risk of hepatotoxicity involving hepatocellular damage. Alternatively, a drug’s INJURYMARKERS expression profile can be generated simultaneously with the above-described training set (or an equivalent set) run in parallel with the test drug, and expression levels associated with the test drug directly compared to those of the training set.

GENERAL METHODS

The RISKMARKER (*i.e.* RISKMARKERS 1-8) and INJURYMARKER (*i.e.* INJURYMARKERS 1-10) nucleic acids and encoded polypeptides can be identified using the information provided above. In some embodiments, the RISKMARKER or INJURYMARKER
5 nucleic acids and polypeptide correspond to nucleic acids or polypeptides which include the various sequences (referenced by SEQ ID NOs) disclosed for each RISKMARKER or INJURYMARKER polypeptide.

In its various aspects and embodiments, the invention includes providing a test cell population which includes at least one cell that is capable of expressing one or more of the
10 sequences RISKMARKER 1-8 or INJURYMARKER 1-10. By "capable of expressing" is meant that the gene is present in an intact form in the cell and can be expressed. Expression of one, some, or all of the RISKMARKER or INJURYMARKER sequences is then detected, if present, and, preferably, measured. Using sequence information provided by the database entries for the known sequences, or the sequence information for the newly described sequences,
15 expression of the RISKMARKER or INJURYMARKER sequences can be detected (if present) and measured using techniques well known to one of ordinary skill in the art. For example, sequences within the sequence database entries corresponding to RISKMARKER or INJURYMARKER sequences, or within the sequences disclosed herein, can be used to construct probes for detecting RISKMARKER or INJURYMARKER RNA sequences in, *e.g.*, northern
20 blot hybridization analyses or methods which specifically, and, preferably, quantitatively amplify specific nucleic acid sequences. As another example, the sequences can be used to construct primers for specifically amplifying the RISKMARKER or INJURYMARKER sequences in, *e.g.*, amplification-based detection methods such as reverse-transcription based polymerase chain reaction. When alterations in gene expression are associated with gene amplification or deletion,
25 sequence comparisons in test and reference populations can be made by comparing relative amounts of the examined DNA sequences in the test and reference cell populations.

Expression can be also measured at the protein level, *i.e.*, by measuring the levels of polypeptides encoded by the gene products described herein. Such methods are well known in the art and include, *e.g.*, immunoassays based on antibodies to proteins encoded by the genes.

Expression level of one or more of the RISKMARKER or INJURYMARKER sequences in the test cell population, *e.g.* rat hepatocytes, is then compared to expression levels of the sequences in one or more cells from a reference cell population. Expression of sequences in test and control populations of cells can be compared using any art-recognized method for comparing expression of nucleic acid sequences. For example, expression can be compared using GENE CALLING[®] methods as described in US Patent No. 5,871,697 and in Shimkets et al., Nat. Biotechnol. 17:798-803.

In various embodiments, the expression of one or more sequences which are markers of hepatotoxicity risk, *i.e.* RISKMARKERS 1-8, is compared. In other embodiments, the expression of one or more sequences which are markers of hepatotoxicity injury type, *i.e.* INJURYMARKERS, is compared. In further embodiments, expression of one or more RISKMARKERS and INJURYMARKERS may be compared to predict both hepatotoxicity risk and type of hepatotoxicity injury.

In various embodiments, the expression of 2, 3, 4, 5, 6, 7, 8, 9, 10, 15, or all of the sequences represented by RISKMARKER 1-8 and INJURYMARKER 1-10 are measured. If desired, expression of these sequences can be measured along with other sequences whose expression is known to be altered according to one of the herein described parameters or conditions.

The reference cell population includes one or more cells for which the compared parameter is known. The compared parameter can be, *e.g.*, hepatotoxic agent expression status. By "hepatotoxic agent expression status" is meant that it is known whether the reference cell has had contact with a hepatotoxic agent. An example of a hepatotoxic agent is, *e.g.*, a thiazolidinedione such as troglitazone. Whether or not comparison of the gene expression profile in the test cell population to the reference cell population reveals the presence, or degree, of the measured parameter depends on the composition of the reference cell population. For example, if the reference cell population is composed of cells that have not been treated with a known hepatotoxic agent, a similar gene expression level in the test cell population and a reference cell population indicates the test agent is not a hepatotoxic agent. Conversely, if the reference cell population is made up of cells that have been treated with a hepatotoxic agent, a similar gene

expression profile between the test cell population and the reference cell population indicates the test agent is a hepatotoxic agent.

In various embodiments, a RISKMARKER or INJURYMARKER sequence in a test cell population is considered comparable in expression level to the expression level of the RISKMARKER or INJURYMARKER sequence if its expression level varies within a factor of 2.0, 1.5, or 1.0 fold to the level of the RISKMARKER or INJURYMARKER transcript in the reference cell population. In various embodiments, a RISKMARKER or INJURYMARKER sequence in a test cell population can be considered altered in levels of expression if its expression level varies from the reference cell population by more than 1.0, 1.5, 2.0 or more fold from the expression level of the corresponding RISKMARKER or INJURYMARKER sequence in the reference cell population.

Alternatively, the absolute expression level matrix of the 8 RISKMARKER and/or 10 INJURYMARKER fragments in a test cell can be transformed using the principal component eigenvectors described above, or similar eigenvalues generated from parallel dosed members of the training set as internal controls. The expression eigenvalues for the test cell can then be compared to the training set eigenvalues described herein, or a parallel-run training set, if any.

The RISKMARKER expression level combination is considered similar to Low Risk idiosyncratic NSAIDS (several of which have been withdrawn), if the test drug's expression profile is within the 95% confidence interval (CI) of the centroid of that risk class. *See* Table 4. The test drug is considered Very Low Risk idiosyncratic if the transformed expression profile falls within the 95% CI of the centroid of that class. The test drug is considered Overdose Risk if the expression profile falls within the 95% CI of the centroid of that class. If the compound fails to associate with any of these compounds it will be categorized as unclassifiable.

Similarly, the INJURYMARKER expression level combination is considered indicative of hepatocellular damage induced by idiosyncratic NSAIDS, if the test drug's expression profile is within the 95% confidence interval (CI) of the centroid of that injury type. *See* Table 6. The test drug is considered to induce idiosyncratic cholestasis if the transformed expression profile falls within the 95% CI of the centroid of that injury type. The test drug is considered to induce elevated transaminase level if the expression profile falls within the 95% CI of the centroid of

that class. If the compound fails to associate with any of these compounds it will be categorized as unclassifiable.

If desired, comparison of differentially expressed sequences between a test cell population and a reference cell population can be done with respect to a control nucleic acid whose expression is independent of the parameter or condition being measured. Expression levels of the control nucleic acid in the test and reference nucleic acid can be used to normalize signal levels in the compared populations.

In some embodiments, the test cell population is compared to multiple reference cell populations. Each of the multiple reference populations may differ in the known parameter. Thus, a test cell population may be compared to a first reference cell population known to have been exposed to a hepatotoxic agent, as well as a second reference population known have not been exposed to a hepatotoxic agent.

The test cell population that is exposed to, *i.e.*, contacted with, the test hepatotoxic agent can be any number of cells, *i.e.*, one or more cells, and can be provided *in vitro*, *in vivo*, or *ex vivo*.

In other embodiments, the test cell population can be divided into two or more subpopulations. The subpopulations can be created by dividing the first population of cells to create as identical a subpopulation as possible. This will be suitable, in, for example, *in vitro* or *ex vivo* screening methods. In some embodiments, various sub populations can be exposed to a control agent, and/or a test agent, multiple test agents, or, *e.g.*, varying dosages of one or multiple test agents administered together, or in various combinations.

Preferably, cells in the reference cell population are derived from a tissue type as similar as possible to test cell, *e.g.*, liver tissue. In some embodiments, the control cell is derived from the same subject as the test cell, *e.g.*, from a region proximal to the region of origin of the test cell. In other embodiments, the reference cell population is derived from a plurality of cells. For example, the reference cell population can be a database of expression patterns from previously tested cells for which one of the herein-described parameters or conditions (hepatotoxic agent expression status is known.

The test agent can be a compound not previously described or can be a previously known compound but which is not known to be a hepatotoxic agent.

The subject is preferably a mammal. The mammal can be, *e.g.*, a human, non-human primate, mouse, rat, dog, cat, horse, or cow.

5 SCREENING FOR TOXIC AGENTS

In one aspect, the invention provides a method of identifying toxic agents, *e.g.*, hepatotoxic agents. The hepatotoxic agent can be identified by providing a cell population that includes cells capable of expressing one or more nucleic acid sequences homologous to those of RISKMARKER 1-8 or INJURYMARKER 1-10. The sequences need not be identical to sequences including RISKMARKER or INJURYMARKER nucleic acid sequences, as long as the sequence is sufficiently similar that specific hybridization can be detected. Preferably, the cell includes sequences that are identical, or nearly identical to those identifying the RISKMARKER or INJURYMARKER nucleic acids described herein.

Expression of the nucleic acid sequences in the test cell population is then compared to the expression of the nucleic acid sequences in a reference cell population, which is a cell population that has not been exposed to the test agent, or, in some embodiments, a cell population exposed the test agent. Comparison can be performed on test and reference samples measured concurrently or at temporally distinct times. An example of the latter is the use of compiled expression information, *e.g.*, a sequence database, which assembles information about expression levels of known sequences following administration of various agents. For example, alteration of expression levels following administration of test agent can be compared to the expression changes observed in the nucleic acid sequences following administration of a control agent, *e.g.* a NSAID such as ketoprofen.

An alteration in expression of the nucleic acid sequence in the test cell population compared to the expression of the nucleic acid sequence in the reference cell population that has not been exposed to the test agent indicates the test agent is a hepatotoxic agent.

The invention also includes a hepatotoxic agent identified according to this screening method.

In some embodiments of the method of the invention, the test agent is an idiosyncratic hepatotoxic agent, *e.g.* a NSAID, and the reference agent is also a NSAID. As described above, RISKMARKER (*e.g.* RISKMARKERS 1-8) expression level patterns can be used to predict the level of hepatotoxicity risk (*i.e.* low, very low, or overdose) associated with a given test agent, *e.g.* a NSAID. In one embodiment, the reference NSAID (*i.e.* used with the reference cell population) is a NSAID classified as having a low risk of hepatotoxicity. The test agent is then identified as having a low risk of hepatotoxicity if no qualitative difference in expression levels is identified in comparison to expression levels in the reference population exposed to a low risk NSAID. In certain embodiments, the low risk NSAID is Benoxaprofen, Bromfenac, Diclofenac, Phenylbutazone, or Sulindac. In another embodiment, the reference NSAID is a NSAID classified as having a very low risk of hepatotoxicity. The test agent is then identified as having a very low risk of hepatotoxicity if no qualitative difference in expression levels is identified in comparison to expression levels in the reference population exposed to a very low risk NSAID. In certain embodiments, the very low risk NSAID is Etodolac, Fenoprofen, Flurbiprofen, Ibuprofen, Indomethacin, Ketoprofen, Meclofenamate, Mefenamic Acid, Nabumetone, Naproxen, Oxaprozin, Piroxicam, Suprofen, Tenoxicam, Tolmentin, or Zomepirac. In still another embodiment, the reference NSAID is a NSAID classified as having an overdose risk of hepatotoxicity. The test agent is then identified as having an overdose risk of hepatotoxicity if no qualitative difference in expression levels is identified in comparison to expression levels in the reference population exposed to an overdose risk NSAID. In certain embodiments, the overdose risk NSAID is Acetaminophen, Acetylsalicylic acid, or Phenacetin. In some embodiments, the difference in expression levels is determined by comparing expression transformation eigenvectors (for risk class) for the test cell and reference cell populations, as described above.

As also described above, INJURYMARKER (*e.g.* INJURYMARKERS 1-10) expression level patterns can be used to predict the type of hepatotoxicity injury (*i.e.* hepatocellular damage, cholestasis, or elevated transaminase level) associated with a given test agent, *e.g.* a NSAID. In some embodiments, the reference NSAID is a NSAID classified as inducing hepatocellular damage. The test agent is then identified as likely to induce hepatocellular damage if no qualitative difference in expression levels is identified in comparison to expression levels in the reference population exposed to a NSAID which induces hepatocellular damage. In certain embodiments, the hepatocellular damage inducing NSAID is Acetaminophen, Flurbiprofen, or

Ketoprofen. In another embodiment, the reference NSAID is a NSAID classified as inducing cholestasis. The test agent is then identified as likely to induce cholestasis if no qualitative difference in expression levels is identified in comparison to expression levels in the reference population exposed to a NSAID which induces cholestasis. In certain embodiments, the cholestatis-inducing NSAID is Benoxaprofen, Nabumetone, or Sulindac. In yet another embodiment, the reference NSAID is a NSAID classified as inducing elevated transaminase level. The test agent is then identified as likely to induce elevated transaminase level if no qualitative difference in expression levels is identified as compared to expression levels in the reference population exposed to a NSAID which induces elevated transaminase levels. In certain embodiments, the elevated transaminase level inducing NSAID is Zomepirac, Mefenamic acid, or Tenoxicam. In some embodiments, the difference in expression levels is determined by comparing expression transformation eigenvectors for said test cell and reference cell populations, as described above.

ASSESSING TOXICITY OF A TOXIC AGENT IN A SUBJECT

The differentially expressed RISKMARKER or INJURYMARKER sequences identified herein also allow for the hepatotoxicity of a hepatotoxic agent to be determined or monitored. In this method, a test cell population from a subject is exposed to a test agent, *i.e.* a hepatotoxic agent. If desired, test cell populations can be taken from the subject at various time points before, during, or after exposure to the test agent. Expression of one or more of the RISKMARKER or INJURYMARKER sequences in the cell population is then measured and compared to a reference cell population which includes cells whose hepatotoxic agent expression status is known. Preferably, the reference cells not been exposed to the test agent.

If the reference cell population contains no cells exposed to the treatment, a similarity in expression between RISKMARKER or INJURYMARKER sequences in the test cell population and the reference cell population indicates that the treatment is non-hepatotoxic. However, a difference in expression between RISKMARKER or INJURYMARKER sequences in the test population and this reference cell population indicates the treatment is hepatotoxic.

By "hepatotoxicity" is meant that the agent is damaging or destructive to liver when administered to a subject leads to liver damage.

As described in detail above, RISKMARKER expression patterns can be used to predict the level of hepatotoxicity risk (*e.g.* low risk, very low risk, overdose risk) associated with a test agent or drug, by comparison to RISKMARKER expression levels for reference drugs, *e.g.* NSAIDs, with a given classification of risk (*e.g.* very low risk). Similarly, INJURYMARKER expression patterns can be used to predict the type of hepatotoxicity damage (*e.g.* hepatocellular damage, cholestasis, elevated transaminase level) associated with a test agent or drug, by comparison to INJURYMARKER expression levels for reference drugs, *e.g.* NSAIDs, which induce a given type of hepatotoxic damage (*e.g.* cholestasis).

RISKMARKER NUCLEIC ACIDS

Also provided in the invention are novel nucleic acid comprising a nucleic acid sequence selected from the group consisting of RISKMARKER 1, and RISKMARKERS 6-8, or their complements, as well as vectors and cells including these nucleic acids.

Thus, one aspect of the invention pertains to isolated RISKMARKER nucleic acid molecules that encode RISKMARKER proteins or biologically active portions thereof. Also included are nucleic acid fragments sufficient for use as hybridization probes to identify RISKMARKER-encoding nucleic acids (*e.g.*, RISKMARKER mRNA) and fragments for use as polymerase chain reaction (PCR) primers for the amplification or mutation of RISKMARKER nucleic acid molecules. As used herein, the term “nucleic acid molecule” is intended to include DNA molecules (*e.g.*, cDNA or genomic DNA), RNA molecules (*e.g.*, mRNA), analogs of the DNA or RNA generated using nucleotide analogs, and derivatives, fragments and homologs thereof. The nucleic acid molecule can be single-stranded or double-stranded, but preferably is double-stranded DNA.

“Probes” refer to nucleic acid sequences of variable length, preferably between at least about 10 nucleotides (nt) or as many as about, *e.g.*, 6,000 nt, depending on use. Probes are used in the detection of identical, similar, or complementary nucleic acid sequences. Longer length probes are usually obtained from a natural or recombinant source, are highly specific and much slower to hybridize than oligomers. Probes may be single- or double-stranded and designed to have specificity in PCR, membrane-based hybridization technologies, or ELISA-like technologies.

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An "isolated" nucleic acid molecule is one that is separated from other nucleic acid molecules which are present in the natural source of the nucleic acid. Examples of isolated nucleic acid molecules include, but are not limited to, recombinant DNA molecules contained in a vector, recombinant DNA molecules maintained in a heterologous host cell, partially or substantially purified nucleic acid molecules, and synthetic DNA or RNA molecules. Preferably, an "isolated" nucleic acid is free of sequences which naturally flank the nucleic acid (*i.e.*, sequences located at the 5' and 3' ends of the nucleic acid) in the genomic DNA of the organism from which the nucleic acid is derived. For example, in various embodiments, the isolated RISKMARKER nucleic acid molecule can contain less than about 50 kb, 25 kb, 5 kb, 4 kb, 3 kb, 2 kb, 1 kb, 0.5 kb or 0.1 kb of nucleotide sequences which naturally flank the nucleic acid molecule in genomic DNA of the cell from which the nucleic acid is derived. Moreover, an "isolated" nucleic acid molecule, such as a cDNA molecule, can be substantially free of other cellular material or culture medium when produced by recombinant techniques, or of chemical precursors or other chemicals when chemically synthesized.

15 A nucleic acid molecule of the present invention, *e.g.*, a nucleic acid molecule having the nucleotide sequence of any of RISKMARKER 1, or RISKMARKER 6-8, or a complement of any of these nucleotide sequences, can be isolated using standard molecular biology techniques and the sequence information provided herein. Using all or a portion of these nucleic acid sequences as a hybridization probe, RISKMARKER or INJURYMARKER nucleic acid sequences can be isolated using standard hybridization and cloning techniques (*e.g.*, as described in Sambrook *et al.*, eds., Molecular Cloning: A Laboratory Manual 2nd Ed., Cold Spring Harbor Laboratory Press, Cold Spring Harbor, NY, 1989; and Ausubel, *et al.*, eds., Current Protocols in Molecular Biology, John Wiley & Sons, New York, NY, 1993.)

25 A nucleic acid of the invention can be amplified using cDNA, mRNA or alternatively, genomic DNA, as a template and appropriate oligonucleotide primers according to standard PCR amplification techniques. The nucleic acid so amplified can be cloned into an appropriate vector and characterized by DNA sequence analysis. Furthermore, oligonucleotides corresponding to RISKMARKER nucleotide sequences can be prepared by standard synthetic techniques, *e.g.*, using an automated DNA synthesizer.

As used herein, the term “oligonucleotide” refers to a series of linked nucleotide residues, which oligonucleotide has a sufficient number of nucleotide bases to be used in a PCR reaction. A short oligonucleotide sequence may be based on, or designed from, a genomic or cDNA sequence and is used to amplify, confirm, or reveal the presence of an identical, similar or complementary DNA or RNA in a particular cell or tissue. Oligonucleotides comprise portions of a nucleic acid sequence having at least about 10 nt and as many as 50 nt, preferably about 15 nt to 30 nt. They may be chemically synthesized and may be used as probes.

In another embodiment, an isolated nucleic acid molecule of the invention comprises a nucleic acid molecule that is a complement of the nucleotide sequence shown in RISKMARKER 1, or RISKMARKER 6-8. In another embodiment, an isolated nucleic acid molecule of the invention comprises a nucleic acid molecule that is a complement of the nucleotide sequence shown in any of these sequences, or a portion of any of these nucleotide sequences. A nucleic acid molecule that is complementary to the nucleotide sequence shown in RISKMARKER 1, or RISKMARKER 6-8 is one that is sufficiently complementary to the nucleotide sequence shown, such that it can hydrogen bond with little or no mismatches to the nucleotide sequences shown, thereby forming a stable duplex.

As used herein, the term “complementary” refers to Watson-Crick or Hoogsteen base pairing between nucleotides units of a nucleic acid molecule, and the term “binding” means the physical or chemical interaction between two polypeptides or compounds or associated polypeptides or compounds or combinations thereof. Binding includes ionic, non-ionic, Von der Waals, hydrophobic interactions, etc. A physical interaction can be either direct or indirect. Indirect interactions may be through or due to the effects of another polypeptide or compound. Direct binding refers to interactions that do not take place through, or due to, the effect of another polypeptide or compound, but instead are without other substantial chemical intermediates.

Moreover, the nucleic acid molecule of the invention can comprise only a portion of the nucleic acid sequence of RISKMARKER 1, or RISKMARKER 6-8, *e.g.*, a fragment that can be used as a probe or primer or a fragment encoding a biologically active portion of RISKMARKER. Fragments provided herein are defined as sequences of at least 6 (contiguous) nucleic acids or at least 4 (contiguous) amino acids, a length sufficient to allow for specific

hybridization in the case of nucleic acids or for specific recognition of an epitope in the case of amino acids, respectively, and are at most some portion less than a full length sequence.

Fragments may be derived from any contiguous portion of a nucleic acid or amino acid sequence of choice. Derivatives are nucleic acid sequences or amino acid sequences formed from the native compounds either directly or by modification or partial substitution. Analogs are nucleic acid sequences or amino acid sequences that have a structure similar to, but not identical to, the native compound but differs from it in respect to certain components or side chains. Analogs may be synthetic or from a different evolutionary origin and may have a similar or opposite metabolic activity compared to wild type.

Derivatives and analogs may be full length or other than full length, if the derivative or analog contains a modified nucleic acid or amino acid, as described below. Derivatives or analogs of the nucleic acids or proteins of the invention include, but are not limited to, molecules comprising regions that are substantially homologous to the nucleic acids or proteins of the invention, in various embodiments, by at least about 45%, 50%, 70%, 80%, 95%, 98%, or even 99% identity (with a preferred identity of 80-99%) over a nucleic acid or amino acid sequence of identical size or when compared to an aligned sequence in which the alignment is done by a computer homology program known in the art, or whose encoding nucleic acid is capable of hybridizing to the complement of a sequence encoding the aforementioned proteins under stringent, moderately stringent, or low stringent conditions. See *e.g.* Ausubel, *et al.*, Current Protocols in Molecular Biology, John Wiley & Sons, New York, NY, 1993, and below. An exemplary program is the Gap program (Wisconsin Sequence Analysis Package, Version 8 for UNIX, Genetics Computer Group, University Research Park, Madison, WI) using the default settings, which uses the algorithm of Smith and Waterman (Adv. Appl. Math., 1981, 2: 482-489, which is incorporated herein by reference in its entirety).

A "homologous nucleic acid sequence" or "homologous amino acid sequence," or variations thereof, refer to sequences characterized by a homology at the nucleotide level or amino acid level as discussed above. Homologous nucleotide sequences encode those sequences coding for isoforms of a RISKMARKER polypeptide. Isoforms can be expressed in different tissues of the same organism as a result of, for example, alternative splicing of RNA.

Alternatively, isoforms can be encoded by different genes. In the present invention, homologous nucleotide sequences include nucleotide sequences encoding for a RISKMARKER polypeptide

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of species other than humans, including, but not limited to, mammals, and thus can include, *e.g.*, mouse, rat, rabbit, dog, cat, cow, horse, and other organisms. Homologous nucleotide sequences also include, but are not limited to, naturally occurring allelic variations and mutations of the nucleotide sequences set forth herein. A homologous nucleotide sequence does not, however, include the nucleotide sequence encoding a human RISKMARKER protein. Homologous nucleic acid sequences include those nucleic acid sequences that encode conservative amino acid substitutions (see below) in a RISKMARKER polypeptide, as well as a polypeptide having a RISKMARKER activity. A homologous amino acid sequence does not encode the amino acid sequence of a human RISKMARKER polypeptide.

The nucleotide sequence determined from the cloning of human RISKMARKER genes allows for the generation of probes and primers designed for use in identifying and/or cloning RISKMARKER homologues in other cell types, *e.g.*, from other tissues, as well as RISKMARKER homologues from other mammals. The probe/primer typically comprises a substantially purified oligonucleotide. The oligonucleotide typically comprises a region of nucleotide sequence that hybridizes under stringent conditions to at least about 12, 25, 50, 100, 150, 200, 250, 300, 350 or 400 consecutive sense strand nucleotide sequence of a nucleic acid comprising a RISKMARKER sequence, or an anti-sense strand nucleotide sequence of a nucleic acid comprising a RISKMARKER sequence, or of a naturally occurring mutant of these sequences.

Probes based on human RISKMARKER nucleotide sequences can be used to detect transcripts or genomic sequences encoding the same or homologous proteins. In various embodiments, the probe further comprises a label group attached thereto, *e.g.*, the label group can be a radioisotope, a fluorescent compound, an enzyme, or an enzyme co-factor. Such probes can be used as a part of a diagnostic test kit for identifying cells or tissue which misexpress a RISKMARKER protein, such as by measuring a level of a RISKMARKER-encoding nucleic acid in a sample of cells from a subject *e.g.*, detecting RISKMARKER mRNA levels or determining whether a genomic RISKMARKER gene has been mutated or deleted.

“A polypeptide having a biologically active portion of RISKMARKER” refers to polypeptides exhibiting activity similar, but not necessarily identical to, an activity of a polypeptide of the present invention, including mature forms, as measured in a particular

biological assay, with or without dose dependency. A nucleic acid fragment encoding a "biologically active portion of RISKMARKER" can be prepared by isolating a portion of RISKMARKER 1, or RISKMARKER 6-8, that encodes a polypeptide having a RISKMARKER biological activity, expressing the encoded portion of RISKMARKER protein (*e.g.*, by recombinant expression *in vitro*) and assessing the activity of the encoded portion of RISKMARKER. For example, a nucleic acid fragment encoding a biologically active portion of a RISKMARKER polypeptide can optionally include an ATP-binding domain. In another embodiment, a nucleic acid fragment encoding a biologically active portion of RISKMARKER includes one or more regions.

RISKMARKER AND INJURYMARKER VARIANTS

The invention further encompasses nucleic acid molecules that differ from the disclosed or referenced RISKMARKER or INJURYMARKER nucleotide sequences due to degeneracy of the genetic code. These nucleic acids thus encode the same RISKMARKER or INJURYMARKER protein as that encoded by nucleotide sequence comprising a RISKMARKER or INJURYMARKER nucleic acid as shown in, *e.g.*, RISKMARKER 1-8 INJURYMARKER 1-10.

In addition to the rat RISKMARKER or INJURYMARKER nucleotide sequence shown in RISKMARKER or INJURYMARKER 1, and RISKMARKER or INJURYMARKER 6-8, it will be appreciated by those skilled in the art that DNA sequence polymorphisms that lead to changes in the amino acid sequences of a RISKMARKER or INJURYMARKER polypeptide may exist within a population (*e.g.*, the human population). Such genetic polymorphism in the RISKMARKER or INJURYMARKER gene may exist among individuals within a population due to natural allelic variation. As used herein, the terms "gene" and "recombinant gene" refer to nucleic acid molecules comprising an open reading frame encoding a RISKMARKER or INJURYMARKER protein, preferably a mammalian RISKMARKER or INJURYMARKER protein. Such natural allelic variations can typically result in 1-5% variance in the nucleotide sequence of the RISKMARKER or INJURYMARKER gene. Any and all such nucleotide variations and resulting amino acid polymorphisms in RISKMARKER or INJURYMARKER

that are the result of natural allelic variation and that do not alter the functional activity of RISKMARKER or INJURYMARKER are intended to be within the scope of the invention.

Moreover, nucleic acid molecules encoding RISKMARKER or INJURYMARKER proteins from other species, and thus that have a nucleotide sequence that differs from the human sequence of RISKMARKER OR INJURYMARKER, are intended to be within the scope of the invention. Nucleic acid molecules corresponding to natural allelic variants and homologues of the RISKMARKER or INJURYMARKER DNAs of the invention can be isolated based on their homology to the human RISKMARKER or INJURYMARKER nucleic acids disclosed herein using the human cDNAs, or a portion thereof, as a hybridization probe according to standard hybridization techniques under stringent hybridization conditions. For example, a soluble human RISKMARKER or INJURYMARKER DNA can be isolated based on its homology to human membrane-bound RISKMARKER or INJURYMARKER. Likewise, a membrane-bound human RISKMARKER or INJURYMARKER DNA can be isolated based on its homology to soluble human RISKMARKER or INJURYMARKER.

Accordingly, in another embodiment, an isolated nucleic acid molecule of the invention is at least 6 nucleotides in length and hybridizes under stringent conditions to the nucleic acid molecule comprising the nucleotide sequence of RISKMARKER 1, or RISKMARKER 6-8. In another embodiment, the nucleic acid is at least 10, 25, 50, 100, 250 or 500 nucleotides in length. In another embodiment, an isolated nucleic acid molecule of the invention hybridizes to the coding region. As used herein, the term "hybridizes under stringent conditions" is intended to describe conditions for hybridization and washing under which nucleotide sequences at least 60% homologous to each other typically remain hybridized to each other.

Homologs (*i.e.*, nucleic acids encoding RISKMARKER or INJURYMARKER proteins derived from species other than human) or other related sequences (*e.g.*, paralogs) can be obtained by low, moderate or high stringency hybridization with all or a portion of the particular human sequence as a probe using methods well known in the art for nucleic acid hybridization and cloning.

As used herein, the phrase "stringent hybridization conditions" refers to conditions under which a probe, primer or oligonucleotide will hybridize to its target sequence, but to no other sequences. Stringent conditions are sequence-dependent and will be different in different

circumstances. Longer sequences hybridize specifically at higher temperatures than shorter sequences. Generally, stringent conditions are selected to be about 5°C lower than the thermal melting point (T_m) for the specific sequence at a defined ionic strength and pH. The T_m is the temperature (under defined ionic strength, pH and nucleic acid concentration) at which 50% of the probes complementary to the target sequence hybridize to the target sequence at equilibrium. Since the target sequences are generally present at excess, at T_m, 50% of the probes are occupied at equilibrium. Typically, stringent conditions will be those in which the salt concentration is less than about 1.0 M sodium ion, typically about 0.01 to 1.0 M sodium ion (or other salts) at pH 7.0 to 8.3 and the temperature is at least about 30°C for short probes, primers or oligonucleotides (e.g., 10 nt to 50 nt) and at least about 60°C for longer probes, primers and oligonucleotides. Stringent conditions may also be achieved with the addition of destabilizing agents, such as formamide.

Stringent conditions are known to those skilled in the art and can be found in Current Protocols in Molecular Biology, John Wiley & Sons, N.Y. (1989), 6.3.1-6.3.6. Preferably, the conditions are such that sequences at least about 65%, 70%, 75%, 85%, 90%, 95%, 98%, or 99% homologous to each other typically remain hybridized to each other. A non-limiting example of stringent hybridization conditions is hybridization in a high salt buffer comprising 6X SSC, 50 mM Tris-HCl (pH 7.5), 1 mM EDTA, 0.02% PVP, 0.02% Ficoll, 0.02% BSA, and 500 mg/ml denatured salmon sperm DNA at 65°C. This hybridization is followed by one or more washes in 0.2X SSC, 0.01% BSA at 50°C. An isolated nucleic acid molecule of the invention that hybridizes under stringent conditions to the sequence of RISKMARKER 1, or RISKMARKER 6-8 corresponds to a naturally occurring nucleic acid molecule. As used herein, a "naturally-occurring" nucleic acid molecule refers to an RNA or DNA molecule having a nucleotide sequence that occurs in nature (*e.g.*, encodes a natural protein).

In a second embodiment, a nucleic acid sequence that is hybridizable to the nucleic acid molecule comprising the nucleotide sequence of RISKMARKER 1, or RISKMARKER 6-8, or fragments, analogs or derivatives thereof, under conditions of moderate stringency is provided. A non-limiting example of moderate stringency hybridization conditions are hybridization in 6X SSC, 5X Denhardt's solution, 0.5% SDS and 100 mg/ml denatured salmon sperm DNA at 55°C, followed by one or more washes in 1X SSC, 0.1% SDS at 37°C. Other conditions of moderate stringency that may be used are well known in the art. See, *e.g.*, Ausubel *et al.* (eds.), 1993,

Current Protocols in Molecular Biology, John Wiley & Sons, NY, and Kriegler, 1990, Gene Transfer and Expression, A Laboratory Manual, Stockton Press, NY.

In a third embodiment, a nucleic acid that is hybridizable to the nucleic acid molecule comprising the nucleotide sequence of RISKMARKER 1, or RISKMARKER 6-8, or fragments, analogs or derivatives thereof, under conditions of low stringency, is provided. A non-limiting example of low stringency hybridization conditions are hybridization in 35% formamide, 5X SSC, 50 mM Tris-HCl (pH 7.5), 5 mM EDTA, 0.02% PVP, 0.02% Ficoll, 0.2% BSA, 100 mg/ml denatured salmon sperm DNA, 10% (wt/vol) dextran sulfate at 40°C, followed by one or more washes in 2X SSC, 25 mM Tris-HCl (pH 7.4), 5 mM EDTA, and 0.1% SDS at 50°C.

Other conditions of low stringency that may be used are well known in the art (*e.g.*, as employed for cross-species hybridizations). See, *e.g.*, Ausubel *et al.* (eds.), 1993, Current Protocols in Molecular Biology, John Wiley & Sons, NY, and Kriegler, 1990, Gene Transfer and Expression, A Laboratory Manual, Stockton Press, NY; Shilo et al., 1981, *Proc Natl Acad Sci USA* 78: 6789-6792.

CONSERVATIVE MUTATIONS

In addition to naturally-occurring allelic variants of the RISKMARKER sequence that may exist in the population, the skilled artisan will further appreciate that changes can be introduced into an RISKMARKER nucleic acid or directly into an RISKMARKER polypeptide sequence without altering the functional ability of the RISKMARKER protein. In some embodiments, the nucleotide sequence of RISKMARKER 1, or RISKMARKER 6-8 will be altered, thereby leading to changes in the amino acid sequence of the encoded RISKMARKER protein. For example, nucleotide substitutions that result in amino acid substitutions at various "non-essential" amino acid residues can be made in the sequence of RISKMARKER 1, or RISKMARKER 6-8. A "non-essential" amino acid residue is a residue that can be altered from the wild-type sequence of RISKMARKER without altering the biological activity, whereas an "essential" amino acid residue is required for biological activity. For example, amino acid residues that are conserved among the RISKMARKER proteins of the present invention, are predicted to be particularly unamenable to alteration.

In addition, amino acid residues that are conserved among family members of the RISKMARKER proteins of the present invention, are also predicted to be particularly unamenable to alteration. As such, these conserved domains are not likely to be amenable to mutation. Other amino acid residues, however, (*e.g.*, those that are not conserved or only semi-conserved among members of the RISKMARKER proteins) may not be essential for activity and thus are likely to be amenable to alteration.

Another aspect of the invention pertains to nucleic acid molecules encoding RISKMARKER proteins that contain changes in amino acid residues that are not essential for activity. Such RISKMARKER proteins differ in amino acid sequence from the amino acid sequences of polypeptides encoded by nucleic acids containing RISKMARKER 1, or RISKMARKER 6-8, yet retain biological activity. In one embodiment, the isolated nucleic acid molecule comprises a nucleotide sequence encoding a protein, wherein the protein comprises an amino acid sequence at least about 45% homologous, more preferably 60%, and still more preferably at least about 70%, 80%, 90%, 95%, 98%, and most preferably at least about 99% homologous to the amino acid sequence of the amino acid sequences of polypeptides encoded by nucleic acids comprising RISKMARKER 1, or RISKMARKER 6-8.

An isolated nucleic acid molecule encoding a RISKMARKER protein homologous to can be created by introducing one or more nucleotide substitutions, additions or deletions into the nucleotide sequence of a nucleic acid comprising RISKMARKER 1, or RISKMARKER 6-8, such that one or more amino acid substitutions, additions or deletions are introduced into the encoded protein.

Mutations can be introduced into a nucleic acid comprising RISKMARKER 1, or RISKMARKER 6-8 by standard techniques, such as site-directed mutagenesis and PCR-mediated mutagenesis. Preferably, conservative amino acid substitutions are made at one or more predicted non-essential amino acid residues. A "conservative amino acid substitution" is one in which the amino acid residue is replaced with an amino acid residue having a similar side chain. Families of amino acid residues having similar side chains have been defined in the art. These families include amino acids with basic side chains (*e.g.*, lysine, arginine, histidine), acidic side chains (*e.g.*, aspartic acid, glutamic acid), uncharged polar side chains (*e.g.*, glycine, asparagine, glutamine, serine, threonine, tyrosine, cysteine), nonpolar side chains (*e.g.*, alanine,

valine, leucine, isoleucine, proline, phenylalanine, methionine, tryptophan), beta-branched side chains (*e.g.*, threonine, valine, isoleucine) and aromatic side chains (*e.g.*, tyrosine, phenylalanine, tryptophan, histidine). Thus, a predicted nonessential amino acid residue in RISKMARKER is replaced with another amino acid residue from the same side chain family. Alternatively, in another embodiment, mutations can be introduced randomly along all or part of a RISKMARKER coding sequence, such as by saturation mutagenesis, and the resultant mutants can be screened for RISKMARKER biological activity to identify mutants that retain activity. Following mutagenesis of the nucleic acid, the encoded protein can be expressed by any recombinant technology known in the art and the activity of the protein can be determined.

In one embodiment, a mutant RISKMARKER protein can be assayed for (1) the ability to form protein:protein interactions with other RISKMARKER proteins, other cell-surface proteins, or biologically active portions thereof, (2) complex formation between a mutant RISKMARKER protein and a RISKMARKER ligand; (3) the ability of a mutant RISKMARKER protein to bind to an intracellular target protein or biologically active portion thereof; (*e.g.*, avidin proteins); (4) the ability to bind ATP; or (5) the ability to specifically bind a RISKMARKER protein antibody.

In other embodiment, the fragment of the complementary polynucleotide sequence described in claim 1 wherein the fragment of the complementary polynucleotide sequence hybridizes to the first sequence.

In other specific embodiments, the nucleic acid is RNA or DNA. The fragment or the fragment of the complementary polynucleotide sequence described in claim 38, wherein the fragment is between about 10 and about 100 nucleotides in length, *e.g.*, between about 10 and about 90 nucleotides in length, or about 10 and about 75 nucleotides in length, about 10 and about 50 bases in length, about 10 and about 40 bases in length, or about 15 and about 30 bases in length.

ANTI-SENSE

Another aspect of the invention pertains to isolated antisense nucleic acid molecules that are hybridizable to or complementary to the nucleic acid molecule comprising the nucleotide sequence of a RISKMARKER or INJURYMARKER sequence or fragments, analogs or derivatives thereof. An "antisense" nucleic acid comprises a nucleotide sequence that is

complementary to a "sense" nucleic acid encoding a protein, *e.g.*, complementary to the coding strand of a double-stranded cDNA molecule or complementary to an mRNA sequence. In specific aspects, antisense nucleic acid molecules are provided that comprise a sequence complementary to at least about 10, 25, 50, 100, 250 or 500 nucleotides or an entire

5 RISKMARKER or INJURYMARKER coding strand, or to only a portion thereof. Nucleic acid molecules encoding fragments, homologs, derivatives and analogs of a RISKMARKER or INJURYMARKER protein, or antisense nucleic acids complementary to a nucleic acid comprising a RISKMARKER or INJURYMARKER nucleic acid sequence are additionally provided.

10 In one embodiment, an antisense nucleic acid molecule is antisense to a "coding region" of the coding strand of a nucleotide sequence encoding RISKMARKER or INJURYMARKER. The term "coding region" refers to the region of the nucleotide sequence comprising codons which are translated into amino acid residues. In another embodiment, the antisense nucleic acid molecule is antisense to a "noncoding region" of the coding strand of a nucleotide sequence
15 encoding RISKMARKER. The term "noncoding region" refers to 5' and 3' sequences which flank the coding region that are not translated into amino acids (*i.e.*, also referred to as 5' and 3' untranslated regions).

Given the coding strand sequences encoding RISKMARKER or INJURYMARKER disclosed herein, antisense nucleic acids of the invention can be designed according to the rules
20 of Watson and Crick or Hoogsteen base pairing. The antisense nucleic acid molecule can be complementary to the entire coding region of RISKMARKER or INJURYMARKER mRNA, but more preferably is an oligonucleotide that is antisense to only a portion of the coding or noncoding region of RISKMARKER or INJURYMARKER mRNA. For example, the antisense oligonucleotide can be complementary to the region surrounding the translation start site of
25 RISKMARKER or INJURYMARKER mRNA. An antisense oligonucleotide can be, for example, about 5, 10, 15, 20, 25, 30, 35, 40, 45 or 50 nucleotides in length. An antisense nucleic acid of the invention can be constructed using chemical synthesis or enzymatic ligation reactions using procedures known in the art. For example, an antisense nucleic acid (*e.g.*, an antisense oligonucleotide) can be chemically synthesized using naturally occurring nucleotides or
30 variously modified nucleotides designed to increase the biological stability of the molecules or to

increase the physical stability of the duplex formed between the antisense and sense nucleic acids, *e.g.*, phosphorothioate derivatives and acridine substituted nucleotides can be used.

Examples of modified nucleotides that can be used to generate the antisense nucleic acid include: 5-fluorouracil, 5-bromouracil, 5-chlorouracil, 5-iodouracil, hypoxanthine, xanthine, 4-acetylcytosine, 5-(carboxyhydroxymethyl) uracil, 5-carboxymethylaminomethyl-2-thiouridine, 5-carboxymethylaminomethyluracil, dihydrouracil, beta-D-galactosylqueosine, inosine, N6-isopentenyladenine, 1-methylguanine, 1-methylinosine, 2,2-dimethylguanine, 2-methyladenine, 2-methylguanine, 3-methylcytosine, 5-methylcytosine, N6-adenine, 7-methylguanine, 5-methylaminomethyluracil, 5-methoxyaminomethyl-2-thiouracil, beta-D-mannosylqueosine, 5'-methoxycarboxymethyluracil, 5-methoxyuracil, 2-methylthio-N6-isopentenyladenine, uracil-5-oxyacetic acid (v), wybutoxosine, pseudouracil, queosine, 2-thiocytosine, 5-methyl-2-thiouracil, 2-thiouracil, 4-thiouracil, 5-methyluracil, uracil-5-oxyacetic acid methylester, uracil-5-oxyacetic acid (v), 5-methyl-2-thiouracil, 3-(3-amino-3-N-2-carboxypropyl) uracil, (acp3)w, and 2,6-diaminopurine. Alternatively, the antisense nucleic acid can be produced biologically using an expression vector into which a nucleic acid has been subcloned in an antisense orientation (*i.e.*, RNA transcribed from the inserted nucleic acid will be of an antisense orientation to a target nucleic acid of interest, described further in the following subsection).

The antisense nucleic acid molecules of the invention are typically administered to a subject or generated *in situ* such that they hybridize with or bind to cellular mRNA and/or genomic DNA encoding a RISKMARKER or INJURYMARKER protein to thereby inhibit expression of the protein, *e.g.*, by inhibiting transcription and/or translation. The hybridization can be by conventional nucleotide complementarity to form a stable duplex, or, for example, in the case of an antisense nucleic acid molecule that binds to DNA duplexes, through specific interactions in the major groove of the double helix. An example of a route of administration of antisense nucleic acid molecules of the invention includes direct injection at a tissue site. Alternatively, antisense nucleic acid molecules can be modified to target selected cells and then administered systemically. For example, for systemic administration, antisense molecules can be modified such that they specifically bind to receptors or antigens expressed on a selected cell surface, *e.g.*, by linking the antisense nucleic acid molecules to peptides or antibodies that bind to cell surface receptors or antigens. The antisense nucleic acid molecules can also be delivered

to cells using the vectors described herein. To achieve sufficient intracellular concentrations of antisense molecules, vector constructs in which the antisense nucleic acid molecule is placed under the control of a strong pol II or pol III promoter are preferred.

In yet another embodiment, the antisense nucleic acid molecule of the invention is an α -anomeric nucleic acid molecule. An α -anomeric nucleic acid molecule forms specific double-stranded hybrids with complementary RNA in which, contrary to the usual α -units, the strands run parallel to each other (Gaultier *et al.* (1987) *Nucleic Acids Res* 15: 6625-6641). The antisense nucleic acid molecule can also comprise a 2'-o-methylribonucleotide (Inoue *et al.* (1987) *Nucleic Acids Res* 15: 6131-6148) or a chimeric RNA -DNA analogue (Inoue *et al.* (1987) *FEBS Lett* 215: 327-330).

RIBOZYMES AND PNA MOIETIES

In still another embodiment, an antisense nucleic acid of the invention is a ribozyme. Ribozymes are catalytic RNA molecules with ribonuclease activity that are capable of cleaving a single-stranded nucleic acid, such as an mRNA, to which they have a complementary region. Thus, ribozymes (*e.g.*, hammerhead ribozymes (described in Haselhoff and Gerlach (1988) *Nature* 334:585-591)) can be used to catalytically cleave RISKMARKER or INJURYMARKER mRNA transcripts to thereby inhibit translation of RISKMARKER or INJURYMARKER mRNA. A ribozyme having specificity for a RISKMARKER or INJURYMARKER -encoding nucleic acid can be designed based upon the nucleotide sequence of a RISKMARKER or INJURYMARKER DNA disclosed herein. For example, a derivative of a Tetrahymena L-19 IVS RNA can be constructed in which the nucleotide sequence of the active site is complementary to the nucleotide sequence to be cleaved in a RISKMARKER or INJURYMARKER-encoding mRNA. See, *e.g.*, Cech *et al.* U.S. Pat. No. 4,987,071; and Cech *et al.* U.S. Pat. No. 5,116,742. Alternatively, RISKMARKER or INJURYMARKER mRNA can be used to select a catalytic RNA having a specific ribonuclease activity from a pool of RNA molecules. See, *e.g.*, Bartel *et al.*, (1993) *Science* 261:1411-1418.

Alternatively, RISKMARKER or INJURYMARKER gene expression can be inhibited by targeting nucleotide sequences complementary to the regulatory region of a RISKMARKER or INJURYMARKER nucleic acid (*e.g.*, the RISKMARKER or INJURYMARKER promoter

and/or enhancers) to form triple helical structures that prevent transcription of the RISKMARKER or INJURYMARKER gene in target cells. See generally, Helene. (1991) *Anticancer Drug Des.* 6: 569-84; Helene. *et al.* (1992) *Ann. N.Y. Acad. Sci.* 660:27-36; and Maher (1992) *Bioassays* 14: 807-15.

5 In various embodiments, the nucleic acids of RISKMARKER or INJURYMARKER can be modified at the base moiety, sugar moiety or phosphate backbone to improve, *e.g.*, the stability, hybridization, or solubility of the molecule. For example, the deoxyribose phosphate backbone of the nucleic acids can be modified to generate peptide nucleic acids (see Hyrup *et al.* (1996) *Bioorg Med Chem* 4: 5-23). As used herein, the terms "peptide nucleic acids" or "PNAs" 10 refer to nucleic acid mimics, *e.g.*, DNA mimics, in which the deoxyribose phosphate backbone is replaced by a pseudopeptide backbone and only the four natural nucleobases are retained. The neutral backbone of PNAs has been shown to allow for specific hybridization to DNA and RNA under conditions of low ionic strength. The synthesis of PNA oligomers can be performed using standard solid phase peptide synthesis protocols as described in Hyrup *et al.* (1996) above; 15 Perry-O'Keefe *et al.* (1996) *PNAS* 93: 14670-675.

PNAs of RISKMARKER or INJURYMARKER can be used in therapeutic and diagnostic applications. For example, PNAs can be used as antisense or antigene agents for sequence-specific modulation of gene expression by, *e.g.*, inducing transcription or translation arrest or inhibiting replication. PNAs of RISKMARKER or INJURYMARKER can also be 20 used, *e.g.*, in the analysis of single base pair mutations in a gene by, *e.g.*, PNA directed PCR clamping; as artificial restriction enzymes when used in combination with other enzymes, *e.g.*, S1 nucleases (Hyrup B. (1996) above); or as probes or primers for DNA sequence and hybridization (Hyrup *et al.* (1996), above; Perry-O'Keefe (1996), above).

In another embodiment, PNAs of RISKMARKER or INJURYMARKER can be 25 modified, *e.g.*, to enhance their stability or cellular uptake, by attaching lipophilic or other helper groups to PNA, by the formation of PNA-DNA chimeras, or by the use of liposomes or other techniques of drug delivery known in the art. For example, PNA-DNA chimeras of RISKMARKER or INJURYMARKER can be generated that may combine the advantageous properties of PNA and DNA. Such chimeras allow DNA recognition enzymes, *e.g.*, RNase H 30 and DNA polymerases, to interact with the DNA portion while the PNA portion would provide

high binding affinity and specificity. PNA-DNA chimeras can be linked using linkers of appropriate lengths selected in terms of base stacking, number of bonds between the nucleobases, and orientation (Hyrup (1996) above). The synthesis of PNA-DNA chimeras can be performed as described in Hyrup (1996) above and Finn *et al.* (1996) *Nucl Acids Res* 24: 3357-63. For example, a DNA chain can be synthesized on a solid support using standard phosphoramidite coupling chemistry, and modified nucleoside analogs, *e.g.*, 5'-(4-methoxytrityl)amino-5'-deoxy-thymidine phosphoramidite, can be used between the PNA and the 5' end of DNA (Mag *et al.* (1989) *Nucl Acid Res* 17: 5973-88). PNA monomers are then coupled in a stepwise manner to produce a chimeric molecule with a 5' PNA segment and a 3' DNA segment (Finn *et al.* (1996) above). Alternatively, chimeric molecules can be synthesized with a 5' DNA segment and a 3' PNA segment. See, Petersen *et al.* (1975) *Bioorg Med Chem Lett* 5: 1119-11124.

In other embodiments, the oligonucleotide may include other appended groups such as peptides (*e.g.*, for targeting host cell receptors *in vivo*), or agents facilitating transport across the cell membrane (see, *e.g.*, Letsinger *et al.*, 1989, *Proc. Natl. Acad. Sci. U.S.A.* 86:6553-6556; Lemaitre *et al.*, 1987, *Proc. Natl. Acad. Sci.* 84:648-652; PCT Publication No. W088/09810) or the blood-brain barrier (see, *e.g.*, PCT Publication No. W089/10134). In addition, oligonucleotides can be modified with hybridization triggered cleavage agents (See, *e.g.*, Krol *et al.*, 1988, *BioTechniques* 6:958-976) or intercalating agents. (See, *e.g.*, Zon, 1988, *Pharm. Res.* 5: 539-549). To this end, the oligonucleotide may be conjugated to another molecule, *e.g.*, a peptide, a hybridization triggered cross-linking agent, a transport agent, a hybridization-triggered cleavage agent, etc.

RISKMARKER AND INJURYMARKER POLYPEPTIDES

One aspect of the invention pertains to isolated RISKMARKER or INJURYMARKER proteins, and biologically active portions thereof, or derivatives, fragments, analogs or homologs thereof. Also provided are polypeptide fragments suitable for use as immunogens to raise anti-RISKMARKER or INJURYMARKER antibodies, *e.g.* antibodies against RISKMARKER 1, or RISKMARKER 6-8. In one embodiment, native RISKMARKER or INJURYMARKER proteins can be isolated from cells or tissue sources by an appropriate purification scheme using

standard protein purification techniques. In another embodiment, RISKMARKER or INJURYMARKER proteins are produced by recombinant DNA techniques. Alternative to recombinant expression, a RISKMARKER or INJURYMARKER protein or polypeptide can be synthesized chemically using standard peptide synthesis techniques.

5 An "isolated" or "purified" protein or biologically active portion thereof is substantially free of cellular material or other contaminating proteins from the cell or tissue source from which the RISKMARKER or INJURYMARKER protein is derived, or substantially free from chemical precursors or other chemicals when chemically synthesized. The language "substantially free of cellular material" includes preparations of RISKMARKER or INJURYMARKER protein in
10 which the protein is separated from cellular components of the cells from which it is isolated or recombinantly produced. In one embodiment, the language "substantially free of cellular material" includes preparations of RISKMARKER or INJURYMARKER protein having less than about 30% (by dry weight) of non-RISKMARKER or INJURYMARKER protein (also referred to herein as a "contaminating protein"), more preferably less than about 20% of
15 non-RISKMARKER or INJURYMARKER protein, still more preferably less than about 10% of non-RISKMARKER or INJURYMARKER protein, and most preferably less than about 5% non-RISKMARKER or INJURYMARKER protein. When the RISKMARKER or INJURYMARKER protein or biologically active portion thereof is recombinantly produced, it is also preferably substantially free of culture medium, *i.e.*, culture medium represents less than
20 about 20%, more preferably less than about 10%, and most preferably less than about 5% of the volume of the protein preparation.

The language "substantially free of chemical precursors or other chemicals" includes preparations of RISKMARKER or INJURYMARKER protein in which the protein is separated from chemical precursors or other chemicals that are involved in the synthesis of the protein. In
25 one embodiment, the language "substantially free of chemical precursors or other chemicals" includes preparations of RISKMARKER or INJURYMARKER protein having less than about 30% (by dry weight) of chemical precursors or non-RISKMARKER or INJURYMARKER chemicals, more preferably less than about 20% chemical precursors or non-RISKMARKER or INJURYMARKER chemicals, still more preferably less than about 10% chemical precursors or
30 non-RISKMARKER or INJURYMARKER chemicals, and most preferably less than about 5% chemical precursors or non-RISKMARKER or INJURYMARKER chemicals.

Biologically active portions of a RISKMARKER or INJURYMARKER protein include peptides comprising amino acid sequences sufficiently homologous to or derived from the amino acid sequence of the RISKMARKER or INJURYMARKER protein, *e.g.*, the amino acid sequence encoded by a nucleic acid comprising RISKMARKER or INJURYMARKER 1-20 that include fewer amino acids than the full length RISKMARKER or INJURYMARKER proteins, and exhibit at least one activity of a RISKMARKER or INJURYMARKER protein. Typically, biologically active portions comprise a domain or motif with at least one activity of the RISKMARKER or INJURYMARKER protein. A biologically active portion of a RISKMARKER or INJURYMARKER protein can be a polypeptide which is, for example, 10, 25, 50, 100 or more amino acids in length.

A biologically active portion of a RISKMARKER or INJURYMARKER protein of the present invention may contain at least one of the above-identified domains conserved between the RISKMARKER or INJURYMARKER proteins. An alternative biologically active portion of a RISKMARKER or INJURYMARKER protein may contain at least two of the above-identified domains. Another biologically active portion of a RISKMARKER or INJURYMARKER protein may contain at least three of the above-identified domains. Yet another biologically active portion of a RISKMARKER or INJURYMARKER protein of the present invention may contain at least four of the above-identified domains.

Moreover, other biologically active portions, in which other regions of the protein are deleted, can be prepared by recombinant techniques and evaluated for one or more of the functional activities of a native RISKMARKER or INJURYMARKER protein.

In some embodiments, the RISKMARKER or INJURYMARKER protein is substantially homologous to one of these RISKMARKER or INJURYMARKER proteins and retains its the functional activity, yet differs in amino acid sequence due to natural allelic variation or mutagenesis, as described in detail below.

In specific embodiments, the invention includes an isolated polypeptide comprising an amino acid sequence that is 80% or more identical to the sequence of a polypeptide whose expression is modulated in a mammal to which hepatotoxic agent is administered.

DETERMINING HOMOLOGY BETWEEN TWO OR MORE SEQUENCES

To determine the percent homology of two amino acid sequences or of two nucleic acids, the sequences are aligned for optimal comparison purposes (*e.g.*, gaps can be introduced in the sequence of a first amino acid or nucleic acid sequence for optimal alignment with a second amino or nucleic acid sequence). The amino acid residues or nucleotides at corresponding amino acid positions or nucleotide positions are then compared. When a position in the first sequence is occupied by the same amino acid residue or nucleotide as the corresponding position in the second sequence, then the molecules are homologous at that position (*i.e.*, as used herein amino acid or nucleic acid "homology" is equivalent to amino acid or nucleic acid "identity").

The nucleic acid sequence homology may be determined as the degree of identity between two sequences. The homology may be determined using computer programs known in the art, such as GAP software provided in the GCG program package. See *Needleman and Wunsch* 1970 *J Mol Biol* 48: 443-453. Using GCG GAP software with the following settings for nucleic acid sequence comparison: GAP creation penalty of 5.0 and GAP extension penalty of 0.3, the coding region of the analogous nucleic acid sequences referred to above exhibits a degree of identity preferably of at least 70%, 75%, 80%, 85%, 90%, 95%, 98%, or 99%, with the CDS (encoding) part of a DNA sequence comprising RISKMARKER 1, or RISKMARKER 6-8..

The term "sequence identity" refers to the degree to which two polynucleotide or polypeptide sequences are identical on a residue-by-residue basis over a particular region of comparison. The term "percentage of sequence identity" is calculated by comparing two optimally aligned sequences over that region of comparison, determining the number of positions at which the identical nucleic acid base (*e.g.*, A, T, C, G, U, or I, in the case of nucleic acids) occurs in both sequences to yield the number of matched positions, dividing the number of matched positions by the total number of positions in the region of comparison (*i.e.*, the window size), and multiplying the result by 100 to yield the percentage of sequence identity. The term "substantial identity" as used herein denotes a characteristic of a polynucleotide sequence, wherein the polynucleotide comprises a sequence that has at least 80 percent sequence identity, preferably at least 85 percent identity and often 90 to 95 percent sequence identity, more usually at least 99 percent sequence identity as compared to a reference sequence over a comparison region.

CHIMERIC AND FUSION PROTEINS

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The invention also provides RISKMARKER chimeric or fusion proteins. As used herein, an RISKMARKER "chimeric protein" or "fusion protein" comprises an RISKMARKER polypeptide operatively linked to a non-RISKMARKER polypeptide. A "RISKMARKER polypeptide" refers to a polypeptide having an amino acid sequence corresponding to RISKMARKER, whereas a "non-RISKMARKER polypeptide" refers to a polypeptide having an amino acid sequence corresponding to a protein that is not substantially homologous to the RISKMARKER protein, *e.g.*, a protein that is different from the RISKMARKER protein and that is derived from the same or a different organism. Within an RISKMARKER fusion protein the RISKMARKER polypeptide can correspond to all or a portion of an RISKMARKER protein. In one embodiment, an RISKMARKER fusion protein comprises at least one biologically active portion of an RISKMARKER protein. In another embodiment, an RISKMARKER fusion protein comprises at least two biologically active portions of an RISKMARKER protein. In yet another embodiment, an RISKMARKER fusion protein comprises at least three biologically active portions of an RISKMARKER protein. Within the fusion protein, the term "operatively linked" is intended to indicate that the RISKMARKER polypeptide and the non-RISKMARKER polypeptide are fused in-frame to each other. The non-RISKMARKER polypeptide can be fused to the N-terminus or C-terminus of the RISKMARKER polypeptide.

For example, in one embodiment an RISKMARKER fusion protein comprises an RISKMARKER domain operably linked to the extracellular domain of a second protein. Such fusion proteins can be further utilized in screening assays for compounds which modulate RISKMARKER activity (such assays are described in detail below).

In yet another embodiment, the fusion protein is a GST-RISKMARKER fusion protein in which the RISKMARKER sequences are fused to the C-terminus of the GST (*i.e.*, glutathione S-transferase) sequences. Such fusion proteins can facilitate the purification of recombinant RISKMARKER, *e.g.* RISKMARKER 1, or RISKMARKER 6-8.

In another embodiment, the fusion protein is an RISKMARKER protein containing a heterologous signal sequence at its N-terminus. For example, a native RISKMARKER signal sequence can be removed and replaced with a signal sequence from another protein. In certain

host cells (*e.g.*, mammalian host cells), expression and/or secretion of RISKMARKER can be increased through use of a heterologous signal sequence.

In yet another embodiment, the fusion protein is a RISKMARKER-immunoglobulin fusion protein in which the RISKMARKER sequences comprising one or more domains are fused to sequences derived from a member of the immunoglobulin protein family. The RISKMARKER-immunoglobulin fusion proteins of the invention can be incorporated into pharmaceutical compositions and administered to a subject to inhibit an interaction between a RISKMARKER ligand and a RISKMARKER protein on the surface of a cell, to thereby suppress RISKMARKER-mediated signal transduction *in vivo*. The RISKMARKER-immunoglobulin fusion proteins can be used to affect the bioavailability of an RISKMARKER cognate ligand. Inhibition of the RISKMARKER ligand/RISKMARKER interaction may be useful therapeutically for both the treatments of proliferative and differentiative disorders, as well as modulating (*e.g.* promoting or inhibiting) cell survival. Moreover, the RISKMARKER-immunoglobulin fusion proteins of the invention can be used as immunogens to produce anti-RISKMARKER antibodies in a subject, to purify RISKMARKER ligands, and in screening assays to identify molecules that inhibit the interaction of RISKMARKER with a RISKMARKER ligand.

An RISKMARKER chimeric or fusion protein of the invention can be produced by standard recombinant DNA techniques. For example, DNA fragments coding for the different polypeptide sequences are ligated together in-frame in accordance with conventional techniques, *e.g.*, by employing blunt-ended or stagger-ended termini for ligation, restriction enzyme digestion to provide for appropriate termini, filling-in of cohesive ends as appropriate, alkaline phosphatase treatment to avoid undesirable joining, and enzymatic ligation. In another embodiment, the fusion gene can be synthesized by conventional techniques including automated DNA synthesizers. Alternatively, PCR amplification of gene fragments can be carried out using anchor primers that give rise to complementary overhangs between two consecutive gene fragments that can subsequently be annealed and reamplified to generate a chimeric gene sequence (see, for example, Ausubel *et al.* (eds.) Current Protocols in Molecular Biology, John Wiley & Sons, 1992). Moreover, many expression vectors are commercially available that already encode a fusion moiety (*e.g.*, a GST polypeptide). A RISKMARKER -encoding nucleic

acid can be cloned into such an expression vector such that the fusion moiety is linked in-frame to the RISKMARKER protein.

RISKMARKER AND INJURYMARKER AGONISTS AND ANTAGONISTS

The present invention also pertains to variants of the RISKMARKER or
5 INJURYMARKER proteins that function as either RISKMARKER or INJURYMARKER
agonists (mimetics) or as RISKMARKER or INJURYMARKER antagonists. Variants of the
RISKMARKER or INJURYMARKER protein can be generated by mutagenesis, *e.g.*, discrete
point mutation or truncation of the RISKMARKER or INJURYMARKER protein. An agonist
10 of the RISKMARKER or INJURYMARKER protein can retain substantially the same, or a
subset of, the biological activities of the naturally occurring form of the RISKMARKER or
INJURYMARKER protein. An antagonist of the RISKMARKER or INJURYMARKER protein
can inhibit one or more of the activities of the naturally occurring form of the RISKMARKER or
INJURYMARKER protein by, for example, competitively binding to a downstream or upstream
15 member of a cellular signaling cascade which includes the RISKMARKER or
INJURYMARKER protein. Thus, specific biological effects can be elicited by treatment with a
variant of limited function. In one embodiment, treatment of a subject with a variant having a
subset of the biological activities of the naturally occurring form of the protein has fewer side
effects in a subject relative to treatment with the naturally occurring form of the RISKMARKER
or INJURYMARKER proteins.

20 Variants of the RISKMARKER or INJURYMARKER protein that function as either
RISKMARKER or INJURYMARKER agonists (mimetics) or as RISKMARKER or
INJURYMARKER antagonists can be identified by screening combinatorial libraries of mutants,
e.g., truncation mutants, of the RISKMARKER or INJURYMARKER protein for
RISKMARKER or INJURYMARKER protein agonist or antagonist activity. In one
25 embodiment, a variegated library of RISKMARKER or INJURYMARKER variants is generated
by combinatorial mutagenesis at the nucleic acid level and is encoded by a variegated gene
library. A variegated library of RISKMARKER or INJURYMARKER variants can be produced
by, for example, enzymatically ligating a mixture of synthetic oligonucleotides into gene
sequences such that a degenerate set of potential RISKMARKER or INJURYMARKER

sequences is expressible as individual polypeptides, or alternatively, as a set of larger fusion proteins (*e.g.*, for phage display) containing the set of RISKMARKER or INJURYMARKER sequences therein. There are a variety of methods which can be used to produce libraries of potential RISKMARKER or INJURYMARKER variants from a degenerate oligonucleotide sequence. Chemical synthesis of a degenerate gene sequence can be performed in an automatic DNA synthesizer, and the synthetic gene then ligated into an appropriate expression vector. Use of a degenerate set of genes allows for the provision, in one mixture, of all of the sequences encoding the desired set of potential RISKMARKER or INJURYMARKER sequences. Methods for synthesizing degenerate oligonucleotides are known in the art (see, *e.g.*, Narang (1983) *Tetrahedron* 39:3; Itakura *et al.* (1984) *Annu Rev Biochem* 53:323; Itakura *et al.* (1984) *Science* 198:1056; Ike *et al.* (1983) *Nucl Acid Res* 11:477.

POLYPEPTIDE LIBRARIES

In addition, libraries of fragments of the RISKMARKER or INJURYMARKER protein coding sequence can be used to generate a variegated population of RISKMARKER or INJURYMARKER fragments for screening and subsequent selection of variants of an RISKMARKER or INJURYMARKER protein. In one embodiment, a library of coding sequence fragments can be generated by treating a double stranded PCR fragment of a RISKMARKER or INJURYMARKER coding sequence with a nuclease under conditions wherein nicking occurs only about once per molecule, denaturing the double stranded DNA, renaturing the DNA to form double stranded DNA that can include sense/antisense pairs from different nicked products, removing single stranded portions from reformed duplexes by treatment with S1 nuclease, and ligating the resulting fragment library into an expression vector. By this method, an expression library can be derived which encodes N-terminal and internal fragments of various sizes of the RISKMARKER or INJURYMARKER protein.

Several techniques are known in the art for screening gene products of combinatorial libraries made by point mutations or truncation, and for screening cDNA libraries for gene products having a selected property. Such techniques are adaptable for rapid screening of the gene libraries generated by the combinatorial mutagenesis of RISKMARKER or INJURYMARKER proteins. The most widely used techniques, which are amenable to high

throughput analysis, for screening large gene libraries typically include cloning the gene library into replicable expression vectors, transforming appropriate cells with the resulting library of vectors, and expressing the combinatorial genes under conditions in which detection of a desired activity facilitates isolation of the vector encoding the gene whose product was detected.

- 5 Recursive ensemble mutagenesis (REM), a new technique that enhances the frequency of functional mutants in the libraries, can be used in combination with the screening assays to identify RISKMARKER or INJURYMARKER variants (Arkin and Yourvan (1992) PNAS 89:7811-7815; Delgrave *et al.* (1993) Protein Engineering 6:327-331).

ANTI-RISKMARKER AND ANTI-INJURYMARKER ANTIBODIES

10 An isolated RISKMARKER or INJURYMARKER protein, or a portion or fragment thereof, can be used as an immunogen to generate antibodies that bind RISKMARKER or INJURYMARKER using standard techniques for polyclonal and monoclonal antibody preparation. The full-length RISKMARKER or INJURYMARKER protein can be used or, alternatively, the invention provides antigenic peptide fragments of RISKMARKER or
15 INJURYMARKER for use as immunogens. The antigenic peptide of RISKMARKER or INJURYMARKER comprises at least 8 amino acid residues of the amino acid sequence encoded by a nucleic acid comprising the nucleic acid sequence shown in RISKMARKER 1-8 and INJURYMARKER 1-10 and encompasses an epitope of RISKMARKER or INJURYMARKER such that an antibody raised against the peptide forms a specific immune complex with
20 RISKMARKER or INJURYMARKER. Preferably, the antigenic peptide comprises at least 10 amino acid residues, more preferably at least 15 amino acid residues, even more preferably at least 20 amino acid residues, and most preferably at least 30 amino acid residues. Preferred epitopes encompassed by the antigenic peptide are regions of RISKMARKER or INJURYMARKER that are located on the surface of the protein, *e.g.*, hydrophilic regions. As a
25 means for targeting antibody production, hydropathy plots showing regions of hydrophilicity and hydrophobicity may be generated by any method well known in the art, including, for example, the Kyte Doolittle or the Hopp Woods methods, either with or without Fourier transformation. See, *e.g.*, Hopp and Woods, 1981, Proc. Nat. Acad. Sci. USA 78: 3824-3828; Kyte and Doolittle 1982, J. Mol. Biol. 157: 105-142, each incorporated herein by reference in their entirety.

RISKMARKER or INJURYMARKER polypeptides or derivatives, fragments, analogs or homologs thereof, may be utilized as immunogens in the generation of antibodies that immunospecifically-bind these protein components. The term "antibody" as used herein refers to immunoglobulin molecules and immunologically active portions of immunoglobulin molecules, *i.e.*, molecules that contain an antigen binding site that specifically binds (immunoreacts with) an antigen. Such antibodies include, but are not limited to, polyclonal, monoclonal, chimeric, single chain, F_{ab} and F_{(ab)²} fragments, and an F_{ab} expression library. Various procedures known within the art may be used for the production of polyclonal or monoclonal antibodies to an RISKMARKER or INJURYMARKER protein sequence, *e.g.* RISKMAKER 1 or RISKMAKER 6-8, or derivatives, fragments, analogs or homologs thereof. Some of these proteins are discussed below.

For the production of polyclonal antibodies, various suitable host animals (*e.g.*, rabbit, goat, mouse or other mammal) may be immunized by injection with the native protein, or a synthetic variant thereof, or a derivative of the foregoing. An appropriate immunogenic preparation can contain, for example, recombinantly expressed RISKMARKER or INJURYMARKER protein or a chemically synthesized RISKMARKER or INJURYMARKER polypeptide. The preparation can further include an adjuvant. Various adjuvants used to increase the immunological response include, but are not limited to, Freund's (complete and incomplete), mineral gels (*e.g.*, aluminum hydroxide), surface active substances (*e.g.*, lysolecithin, pluronic polyols, polyanions, peptides, oil emulsions, dinitrophenol, etc.), human adjuvants such as *Bacille Calmette-Guerin* and *Corynebacterium parvum*, or similar immunostimulatory agents. If desired, the antibody molecules directed against RISKMARKER or INJURYMARKER can be isolated from the mammal (*e.g.*, from the blood) and further purified by well known techniques, such as protein A chromatography to obtain the IgG fraction.

The term "monoclonal antibody" or "monoclonal antibody composition", as used herein, refers to a population of antibody molecules that contain only one species of an antigen binding site capable of immunoreacting with a particular epitope of RISKMARKER or INJURYMARKER. A monoclonal antibody composition thus typically displays a single binding affinity for a particular RISKMARKER or INJURYMARKER protein with which it immunoreacts. For preparation of monoclonal antibodies directed towards a particular RISKMARKER or INJURYMARKER protein, or derivatives, fragments, analogs or homologs

thereof, any technique that provides for the production of antibody molecules by continuous cell line culture may be utilized. Such techniques include, but are not limited to, the hybridoma technique (see Kohler & Milstein, 1975 *Nature* 256: 495-497); the trioma technique; the human B-cell hybridoma technique (see Kozbor, *et al.*, 1983 *Immunol Today* 4: 72) and the EBV hybridoma technique to produce human monoclonal antibodies (see Cole, *et al.*, 1985 In: Monoclonal Antibodies and Cancer Therapy, Alan R. Liss, Inc., pp. 77-96). Human monoclonal antibodies may be utilized in the practice of the present invention and may be produced by using human hybridomas (see Cote, *et al.*, 1983. *Proc Natl Acad Sci USA* 80: 2026-2030) or by transforming human B-cells with Epstein Barr Virus *in vitro* (see Cole, *et al.*, 1985 In: Monoclonal Antibodies and Cancer Therapy, Alan R. Liss, Inc., pp. 77-96).

According to the invention, techniques can be adapted for the production of single-chain antibodies specific to a RISKMARKER or INJURYMARKER protein (see *e.g.*, U.S. Patent No. 4,946,778). In addition, methods can be adapted for the construction of F_{ab} expression libraries (see *e.g.*, Huse, *et al.*, 1989 *Science* 246: 1275-1281) to allow rapid and effective identification of monoclonal F_{ab} fragments with the desired specificity for a RISKMARKER or INJURYMARKER protein or derivatives, fragments, analogs or homologs thereof. Non-human antibodies can be "humanized" by techniques well known in the art. See *e.g.*, U.S. Patent No. 5,225,539. Antibody fragments that contain the idiotypes to a RISKMARKER or INJURYMARKER protein may be produced by techniques known in the art including, but not limited to: (i) an F_{(ab')₂} fragment produced by pepsin digestion of an antibody molecule; (ii) an F_{ab} fragment generated by reducing the disulfide bridges of an F_{(ab')₂} fragment; (iii) an F_{ab} fragment generated by the treatment of the antibody molecule with papain and a reducing agent and (iv) F_v fragments.

Additionally, recombinant anti-RISKMARKER or INJURYMARKER antibodies, such as chimeric and humanized monoclonal antibodies, comprising both human and non-human portions, which can be made using standard recombinant DNA techniques, are within the scope of the invention. Such chimeric and humanized monoclonal antibodies can be produced by recombinant DNA techniques known in the art, for example using methods described in PCT International Application No. PCT/US86/02269; European Patent Application No. 184,187; European Patent Application No. 171,496; European Patent Application No. 173,494; PCT International Publication No. WO 86/01533; U.S. Pat. No. 4,816,567; European Patent

Application No. 125,023; Better *et al.* (1988) *Science* 240:1041-1043; Liu *et al.* (1987) *PNAS* 84:3439-3443; Liu *et al.* (1987) *J Immunol.* 139:3521-3526; Sun *et al.* (1987) *PNAS* 84:214-218; Nishimura *et al.* (1987) *Cancer Res* 47:999-1005; Wood *et al.* (1985) *Nature* 314:446-449; Shaw *et al.* (1988) *J Natl Cancer Inst.* 80:1553-1559; Morrison (1985) *Science* 229:1202-1207; Oi *et al.* (1986) *BioTechniques* 4:214; U.S. Pat. No. 5,225,539; Jones *et al.* (1986) *Nature* 321:552-525; Verhoeyan *et al.* (1988) *Science* 239:1534; and Beidler *et al.* (1988) *J Immunol* 141:4053-4060.

In one embodiment, methods for the screening of antibodies that possess the desired specificity include, but are not limited to, enzyme-linked immunosorbent assay (ELISA) and other immunologically-mediated techniques known within the art. In a specific embodiment, selection of antibodies that are specific to a particular domain of a RISKMARKER or INJURYMARKER protein is facilitated by generation of hybridomas that bind to the fragment of a RISKMARKER or INJURYMARKER protein possessing such a domain. Antibodies that are specific for one or more domains within a RISKMARKER or INJURYMARKER protein, *e.g.*, domains spanning the above-identified conserved regions of RISKMARKER or INJURYMARKER family proteins, or derivatives, fragments, analogs or homologs thereof, are also provided herein.

Anti-RISKMARKER or anti-INJURYMARKER antibodies may be used in methods known within the art relating to the localization and/or quantitation of a RISKMARKER or INJURYMARKER protein (*e.g.*, for use in measuring levels of the RISKMARKER or INJURYMARKER protein within appropriate physiological samples, for use in diagnostic methods, for use in imaging the protein, and the like). In a given embodiment, antibodies for RISKMARKER or INJURYMARKER proteins, or derivatives, fragments, analogs or homologs thereof, that contain the antibody derived binding domain, are utilized as pharmacologically-active compounds [hereinafter "Therapeutics"].

An anti-RISKMARKER or INJURYMARKER antibody (*e.g.*, monoclonal antibody) can be used to isolate RISKMARKER or INJURYMARKER by standard techniques, such as affinity chromatography or immunoprecipitation. An anti-RISKMARKER or INJURYMARKER antibody can facilitate the purification of natural RISKMARKER or INJURYMARKER from cells and of recombinantly produced RISKMARKER or INJURYMARKER expressed in host

cells. Moreover, an anti-RISKMARKER or INJURYMARKER antibody can be used to detect RISKMARKER or INJURYMARKER protein (*e.g.*, in a cellular lysate or cell supernatant) in order to evaluate the abundance and pattern of expression of the RISKMARKER or INJURYMARKER protein. Anti-RISKMARKER or INJURYMARKER antibodies can be used

5 diagnostically to monitor protein levels in tissue as part of a clinical testing procedure, *e.g.*, to, for example, determine the efficacy of a given treatment regimen. Detection can be facilitated by coupling (*i.e.*, physically linking) the antibody to a detectable substance. Examples of detectable substances include various enzymes, prosthetic groups, fluorescent materials, luminescent materials, bioluminescent materials, and radioactive materials. Examples of suitable

10 enzymes include horseradish peroxidase, alkaline phosphatase, β -galactosidase, or acetylcholinesterase; examples of suitable prosthetic group complexes include streptavidin/biotin and avidin/biotin; examples of suitable fluorescent materials include umbelliferone, fluorescein, fluorescein isothiocyanate, rhodamine, dichlorotriazinylamine fluorescein, dansyl chloride or phycoerythrin; an example of a luminescent material includes luminol; examples of

15 bioluminescent materials include luciferase, luciferin, and aequorin, and examples of suitable radioactive material include ^{125}I , ^{131}I , ^{35}S or ^3H .

RISKMARKER RECOMBINANT VECTORS AND HOST CELLS

Another aspect of the invention pertains to vectors, preferably expression vectors, containing a nucleic acid encoding RISKMARKER protein, *e.g.*, RISKMARKER 1, or

20 RISKMARKER 6-8, or derivatives, fragments, analogs or homologs thereof. As used herein, the term "vector" refers to a nucleic acid molecule capable of transporting another nucleic acid to which it has been linked. One type of vector is a "plasmid", which refers to a linear or circular double stranded DNA loop into which additional DNA segments can be ligated. Another type of vector is a viral vector, wherein additional DNA segments can be ligated into the viral genome.

25 Certain vectors are capable of autonomous replication in a host cell into which they are introduced (*e.g.*, bacterial vectors having a bacterial origin of replication and episomal mammalian vectors). Other vectors (*e.g.*, non-episomal mammalian vectors) are integrated into the genome of a host cell upon introduction into the host cell, and thereby are replicated along with the host genome. Moreover, certain vectors are capable of directing the expression of genes

30 to which they are operatively linked. Such vectors are referred to herein as "expression vectors".

In general, expression vectors of utility in recombinant DNA techniques are often in the form of plasmids. In the present specification, "plasmid" and "vector" can be used interchangeably as the plasmid is the most commonly used form of vector. However, the invention is intended to include such other forms of expression vectors, such as viral vectors (*e.g.*, replication defective retroviruses, adenoviruses and adeno-associated viruses), which serve equivalent functions.

The recombinant expression vectors of the invention comprise a nucleic acid of the invention in a form suitable for expression of the nucleic acid in a host cell, which means that the recombinant expression vectors include one or more regulatory sequences, selected on the basis of the host cells to be used for expression, that is operatively linked to the nucleic acid sequence to be expressed. Within a recombinant expression vector, "operably linked" is intended to mean that the nucleotide sequence of interest is linked to the regulatory sequence(s) in a manner that allows for expression of the nucleotide sequence (*e.g.*, in an *in vitro* transcription/translation system or in a host cell when the vector is introduced into the host cell). The term "regulatory sequence" is intended to include promoters, enhancers and other expression control elements (*e.g.*, polyadenylation signals). Such regulatory sequences are described, for example, in Goeddel; Gene Expression Technology: Methods in Enzymology 185, Academic Press, San Diego, Calif. (1990). Regulatory sequences include those that direct constitutive expression of a nucleotide sequence in many types of host cell and those that direct expression of the nucleotide sequence only in certain host cells (*e.g.*, tissue-specific regulatory sequences). It will be appreciated by those skilled in the art that the design of the expression vector can depend on such factors as the choice of the host cell to be transformed, the level of expression of protein desired, etc. The expression vectors of the invention can be introduced into host cells to thereby produce proteins or peptides, including fusion proteins or peptides, encoded by nucleic acids as described herein (*e.g.*, RISKMARKER proteins, mutant forms, fusion proteins, etc.).

The recombinant expression vectors of the invention can be designed for expression of RISKMARKER in prokaryotic or eukaryotic cells. For example, RISKMARKER can be expressed in bacterial cells such as *E. coli*, insect cells (using baculovirus expression vectors) yeast cells or mammalian cells. Suitable host cells are discussed further in Goeddel, Gene Expression Technology: Methods in Enzymology 185, Academic Press, San Diego, Calif. (1990). Alternatively, the recombinant expression vector can be transcribed and translated *in vitro*, for example using T7 promoter regulatory sequences and T7 polymerase.

Expression of proteins in prokaryotes is most often carried out in *E. coli* with vectors containing constitutive or inducible promoters directing the expression of either fusion or non-fusion proteins. Fusion vectors add a number of amino acids to a protein encoded therein, usually to the amino terminus of the recombinant protein. Such fusion vectors typically serve three purposes: (1) to increase expression of recombinant protein; (2) to increase the solubility of the recombinant protein; and (3) to aid in the purification of the recombinant protein by acting as a ligand in affinity purification. Often, in fusion expression vectors, a proteolytic cleavage site is introduced at the junction of the fusion moiety and the recombinant protein to enable separation of the recombinant protein from the fusion moiety subsequent to purification of the fusion protein. Such enzymes, and their cognate recognition sequences, include Factor Xa, thrombin and enterokinase. Typical fusion expression vectors include pGEX (Pharmacia Biotech Inc; Smith and Johnson (1988) *Gene* 67:31-40), pMAL (New England Biolabs, Beverly, Mass.) and pRIT5 (Pharmacia, Piscataway, N.J.) that fuse glutathione S-transferase (GST), maltose E binding protein, or protein A, respectively, to the target recombinant protein.

Examples of suitable inducible non-fusion *E. coli* expression vectors include pTrc (Amrann *et al.*, (1988) *Gene* 69:301-315) and pET 11d (Studier *et al.*, *Gene Expression Technology: Methods in Enzymology* 185, Academic Press, San Diego, Calif. (1990) 60-89).

One strategy to maximize recombinant protein expression in *E. coli* is to express the protein in a host bacteria with an impaired capacity to proteolytically cleave the recombinant protein. See, Gottesman, *Gene Expression Technology: Methods in Enzymology* 185, Academic Press, San Diego, Calif. (1990) 119-128. Another strategy is to alter the nucleic acid sequence of the nucleic acid to be inserted into an expression vector so that the individual codons for each amino acid are those preferentially utilized in *E. coli* (Wada *et al.*, (1992) *Nucleic Acids Res.* 20:2111-2118). Such alteration of nucleic acid sequences of the invention can be carried out by standard DNA synthesis techniques.

In another embodiment, the RISKMARKER expression vector is a yeast expression vector. Examples of vectors for expression in yeast *S. cerevisiae* include pYepSec1 (Baldari, *et al.*, (1987) *EMBO J* 6:229-234), pMFa (Kurjan and Herskowitz, (1982) *Cell* 30:933-943), pJRY88 (Schultz *et al.*, (1987) *Gene* 54:113-123), pYES2 (Invitrogen Corporation, San Diego, Calif.), and picZ (Invitrogen Corp, San Diego, Calif.).

Alternatively, RISKMARKER can be expressed in insect cells using baculovirus expression vectors. Baculovirus vectors available for expression of proteins in cultured insect cells (e.g., SF9 cells) include the pAc series (Smith *et al.* (1983) *Mol Cell Biol* 3:2156-2165) and the pVL series (Lucklow and Summers (1989) *Virology* 170:31-39).

5 In yet another embodiment, a nucleic acid of the invention is expressed in mammalian cells using a mammalian expression vector. Examples of mammalian expression vectors include pCDM8 (Seed (1987) *Nature* 329:840) and pMT2PC (Kaufman *et al.* (1987) *EMBO J* 6: 187-195). When used in mammalian cells, the expression vector's control functions are often provided by viral regulatory elements. For example, commonly used promoters are derived from
10 polyoma, Adenovirus 2, cytomegalovirus and Simian Virus 40. For other suitable expression systems for both prokaryotic and eukaryotic cells. See, e.g., Chapters 16 and 17 of Sambrook *et al.*, Molecular Cloning: A Laboratory Manual. 2nd ed., Cold Spring Harbor Laboratory, Cold Spring Harbor Laboratory Press, Cold Spring Harbor, N.Y., 1989.

15 In another embodiment, the recombinant mammalian expression vector is capable of directing expression of the nucleic acid preferentially in a particular cell type (e.g., tissue-specific regulatory elements are used to express the nucleic acid). Tissue-specific regulatory elements are known in the art. Non-limiting examples of suitable tissue-specific promoters include the albumin promoter (liver-specific; Pinkert *et al.* (1987) *Genes Dev* 1:268-277), lymphoid-specific promoters (Calame and Eaton (1988) *Adv Immunol* 43:235-275),
20 in particular promoters of T cell receptors (Winoto and Baltimore (1989) *EMBO J* 8:729-733) and immunoglobulins (Banerji *et al.* (1983) *Cell* 33:729-740; Queen and Baltimore (1983) *Cell* 33:741-748), neuron-specific promoters (e.g., the neurofilament promoter; Byrne and Ruddie (1989) *PNAS* 86:5473-5477), pancreas-specific promoters (Edlund *et al.* (1985) *Science* 230:912-916), and mammary gland-specific promoters (e.g., milk whey promoter; U.S. Pat. No.
25 4,873,316 and European Application Publication No. 264,166). Developmentally-regulated promoters are also encompassed, e.g., the murine hox promoters (Kessel and Gruss (1990) *Science* 249:374-379) and the α -fetoprotein promoter (Campes and Tilghman (1989) *Genes Dev* 3:537-546).

30 The invention further provides a recombinant expression vector comprising a DNA molecule of the invention cloned into the expression vector in an antisense orientation. That is,

the DNA molecule is operatively linked to a regulatory sequence in a manner that allows for expression (by transcription of the DNA molecule) of an RNA molecule that is antisense to RISKMARKER mRNA. Regulatory sequences operatively linked to a nucleic acid cloned in the antisense orientation can be chosen that direct the continuous expression of the antisense RNA molecule in a variety of cell types, for instance viral promoters and/or enhancers, or regulatory sequences can be chosen that direct constitutive, tissue specific or cell type specific expression of antisense RNA. The antisense expression vector can be in the form of a recombinant plasmid, phagemid or attenuated virus in which antisense nucleic acids are produced under the control of a high efficiency regulatory region, the activity of which can be determined by the cell type into which the vector is introduced. For a discussion of the regulation of gene expression using antisense genes see Weintraub *et al.*, "Antisense RNA as a molecular tool for genetic analysis," Reviews--Trends in Genetics, Vol. 1(1) 1986.

Another aspect of the invention pertains to host cells into which a recombinant expression vector of the invention has been introduced. The terms "host cell" and "recombinant host cell" are used interchangeably herein. It is understood that such terms refer not only to the particular subject cell but also to the progeny or potential progeny of such a cell. Because certain modifications may occur in succeeding generations due to either mutation or environmental influences, such progeny may not, in fact, be identical to the parent cell, but are still included within the scope of the term as used herein.

A host cell can be any prokaryotic or eukaryotic cell. For example, RISKMARKER protein can be expressed in bacterial cells such as *E. coli*, insect cells, yeast or mammalian cells (such as Chinese hamster ovary cells (CHO) or COS cells). Other suitable host cells are known to those skilled in the art.

Vector DNA can be introduced into prokaryotic or eukaryotic cells via conventional transformation or transfection techniques. As used herein, the terms "transformation" and "transfection" are intended to refer to a variety of art-recognized techniques for introducing foreign nucleic acid (*e.g.*, DNA) into a host cell, including calcium phosphate or calcium chloride co-precipitation, DEAE-dextran-mediated transfection, lipofection, or electroporation. Suitable methods for transforming or transfecting host cells can be found in Sambrook, *et al.*

(Molecular Cloning: A Laboratory Manual. 2nd ed., Cold Spring Harbor Laboratory, Cold Spring Harbor Laboratory Press, Cold Spring Harbor, N.Y., 1989), and other laboratory manuals.

For stable transfection of mammalian cells, it is known that, depending upon the expression vector and transfection technique used, only a small fraction of cells may integrate the foreign DNA into their genome. In order to identify and select these integrants, a gene that encodes a selectable marker (*e.g.*, resistance to antibiotics) is generally introduced into the host cells along with the gene of interest. Various selectable markers include those that confer resistance to drugs, such as G418, hygromycin and methotrexate. Nucleic acid encoding a selectable marker can be introduced into a host cell on the same vector as that encoding RISKMARKER or can be introduced on a separate vector. Cells stably transfected with the introduced nucleic acid can be identified by drug selection (*e.g.*, cells that have incorporated the selectable marker gene will survive, while the other cells die).

A host cell of the invention, such as a prokaryotic or eukaryotic host cell in culture, can be used to produce (*i.e.*, express) an RISKMARKER protein, *e.g.* RISKMARKER 1, or RISKMARKER 6-8. Accordingly, the invention further provides methods for producing RISKMARKER protein using the host cells of the invention. In one embodiment, the method comprises culturing the host cell of invention (into which a recombinant expression vector encoding RISKMARKER has been introduced) in a suitable medium such that RISKMARKER protein is produced. In another embodiment, the method further comprises isolating RISKMARKER from the medium or the host cell.

PHARMACEUTICAL COMPOSITIONS

The RISKMARKER nucleic acid molecules, RISKMARKER proteins, and anti-RISKMARKER or anti-INJURYMARKER antibodies (also referred to herein as "active compounds") of the invention, and derivatives, fragments, analogs and homologs thereof, can be incorporated into pharmaceutical compositions suitable for administration. Such compositions typically comprise the nucleic acid molecule, protein, or antibody and a pharmaceutically acceptable carrier. As used herein, "pharmaceutically acceptable carrier" is intended to include any and all solvents, dispersion media, coatings, antibacterial and antifungal agents, isotonic and

absorption delaying agents, and the like, compatible with pharmaceutical administration.

Suitable carriers are described in the most recent edition of Remington's Pharmaceutical Sciences, a standard reference text in the field, which is incorporated herein by reference.

Preferred examples of such carriers or diluents include, but are not limited to, water, saline,

5 finger's solutions, dextrose solution, and 5% human serum albumin. Liposomes and non-aqueous vehicles such as fixed oils may also be used. The use of such media and agents for pharmaceutically active substances is well known in the art. Except insofar as any conventional media or agent is incompatible with the active compound, use thereof in the compositions is contemplated. Supplementary active compounds can also be incorporated into the compositions.

10 A pharmaceutical composition of the invention is formulated to be compatible with its intended route of administration. Examples of routes of administration include parenteral, *e.g.*, intravenous, intradermal, subcutaneous, oral (*e.g.*, inhalation), transdermal (topical), transmucosal, and rectal administration. Solutions or suspensions used for parenteral, intradermal, or subcutaneous application can include the following components: a sterile diluent
15 such as water for injection, saline solution, fixed oils, polyethylene glycols, glycerine, propylene glycol or other synthetic solvents; antibacterial agents such as benzyl alcohol or methyl parabens; antioxidants such as ascorbic acid or sodium bisulfite; chelating agents such as ethylenediaminetetraacetic acid; buffers such as acetates, citrates or phosphates, and agents for the adjustment of tonicity such as sodium chloride or dextrose. The pH can be adjusted with
20 acids or bases, such as hydrochloric acid or sodium hydroxide. The parenteral preparation can be enclosed in ampoules, disposable syringes or multiple dose vials made of glass or plastic.

Pharmaceutical compositions suitable for injectable use include sterile aqueous solutions (where water soluble) or dispersions and sterile powders for the extemporaneous preparation of sterile injectable solutions or dispersion. For intravenous administration, suitable carriers include
25 physiological saline, bacteriostatic water, Cremophor EL™ (BASF, Parsippany, N.J.) or phosphate buffered saline (PBS). In all cases, the composition must be sterile and should be fluid to the extent that easy syringeability exists. It must be stable under the conditions of manufacture and storage and must be preserved against the contaminating action of microorganisms such as bacteria and fungi. The carrier can be a solvent or dispersion medium containing, for example,
30 water, ethanol, polyol (for example, glycerol, propylene glycol, and liquid polyethylene glycol,

and the like), and suitable mixtures thereof. The proper fluidity can be maintained, for example, by the use of a coating such as lecithin, by the maintenance of the required particle size in the case of dispersion and by the use of surfactants. Prevention of the action of microorganisms can be achieved by various antibacterial and antifungal agents, for example, parabens, chlorobutanol, phenol, ascorbic acid, thimerosal, and the like. In many cases, it will be preferable to include isotonic agents, for example, sugars, polyalcohols such as manitol, sorbitol, sodium chloride in the composition. Prolonged absorption of the injectable compositions can be brought about by including in the composition an agent which delays absorption, for example, aluminum monostearate and gelatin.

Sterile injectable solutions can be prepared by incorporating the active compound (*e.g.*, a RISKMARKER protein or anti-RISKMARKER or INJURYMARKER antibody) in the required amount in an appropriate solvent with one or a combination of ingredients enumerated above, as required, followed by filtered sterilization. Generally, dispersions are prepared by incorporating the active compound into a sterile vehicle that contains a basic dispersion medium and the required other ingredients from those enumerated above. In the case of sterile powders for the preparation of sterile injectable solutions, methods of preparation are vacuum drying and freeze-drying that yields a powder of the active ingredient plus any additional desired ingredient from a previously sterile-filtered solution thereof.

Oral compositions generally include an inert diluent or an edible carrier. They can be enclosed in gelatin capsules or compressed into tablets. For the purpose of oral therapeutic administration, the active compound can be incorporated with excipients and used in the form of tablets, troches, or capsules. Oral compositions can also be prepared using a fluid carrier for use as a mouthwash, wherein the compound in the fluid carrier is applied orally and swished and expectorated or swallowed. Pharmaceutically compatible binding agents, and/or adjuvant materials can be included as part of the composition. The tablets, pills, capsules, troches and the like can contain any of the following ingredients, or compounds of a similar nature: a binder such as microcrystalline cellulose, gum tragacanth or gelatin; an excipient such as starch or lactose, a disintegrating agent such as alginic acid, Primogel, or corn starch; a lubricant such as magnesium stearate or Sterotes; a glidant such as colloidal silicon dioxide; a sweetening agent such as sucrose or saccharin; or a flavoring agent such as peppermint, methyl salicylate, or orange flavoring.

For administration by inhalation, the compounds are delivered in the form of an aerosol spray from pressured container or dispenser which contains a suitable propellant, *e.g.*, a gas such as carbon dioxide, or a nebulizer.

Systemic administration can also be by transmucosal or transdermal means. For
5 transmucosal or transdermal administration, penetrants appropriate to the barrier to be permeated are used in the formulation. Such penetrants are generally known in the art, and include, for example, for transmucosal administration, detergents, bile salts, and fusidic acid derivatives. Transmucosal administration can be accomplished through the use of nasal sprays or suppositories. For transdermal administration, the active compounds are formulated into
10 ointments, salves, gels, or creams as generally known in the art. The compounds can also be prepared in the form of suppositories (*e.g.*, with conventional suppository bases such as cocoa butter and other glycerides) or retention enemas for rectal delivery.

In one embodiment, the active compounds are prepared with carriers that will protect the compound against rapid elimination from the body, such as a controlled release formulation,
15 including implants and microencapsulated delivery systems. Biodegradable, biocompatible polymers can be used, such as ethylene vinyl acetate, polyanhydrides, polyglycolic acid, collagen, polyorthoesters, and polylactic acid. Methods for preparation of such formulations will be apparent to those skilled in the art. The materials can also be obtained commercially from Alza Corporation and Nova Pharmaceuticals, Inc. Liposomal suspensions (including liposomes
20 targeted to infected cells with monoclonal antibodies to viral antigens) can also be used as pharmaceutically acceptable carriers. These can be prepared according to methods known to those skilled in the art, for example, as described in U.S. Pat. No. 4,522,811.

It is especially advantageous to formulate oral or parenteral compositions in dosage unit form for ease of administration and uniformity of dosage. Dosage unit form as used herein refers
25 to physically discrete units suited as unitary dosages for the subject to be treated; each unit containing a predetermined quantity of active compound calculated to produce the desired therapeutic effect in association with the required pharmaceutical carrier. The specification for the dosage unit forms of the invention are dictated by and directly dependent on the unique characteristics of the active compound and the particular therapeutic effect to be achieved, and

the limitations inherent in the art of compounding such an active compound for the treatment of individuals.

The nucleic acid molecules of the invention can be inserted into vectors and used as gene therapy vectors. Gene therapy vectors can be delivered to a subject by, for example, intravenous injection, local administration (see U.S. Pat. No. 5,328,470) or by stereotactic injection (see *e.g.*, Chen *et al.* (1994) *PNAS* 91:3054-3057). The pharmaceutical preparation of the gene therapy vector can include the gene therapy vector in an acceptable diluent, or can comprise a slow release matrix in which the gene delivery vehicle is imbedded. Alternatively, where the complete gene delivery vector can be produced intact from recombinant cells, *e.g.*, retroviral vectors, the pharmaceutical preparation can include one or more cells that produce the gene delivery system. The pharmaceutical compositions can be included in a container, pack, or dispenser together with instructions for administration.

KITS AND NUCLEIC ACID COLLECTIONS FOR IDENTIFYING RISKMARKER AND INJURYMARKER NUCLEIC ACIDS

In another aspect, the invention provides a kit useful for examining hepatotoxicity of agents. The kit can include nucleic acids that detect two or more RISKMARKER or INJURYMARKER sequences. In preferred embodiments, the kit includes reagents which detect 3, 4, 5, 6, 8, 10, 12, 15, or all of the RISKMARKER or INJURYMARKER nucleic acid sequences.

The invention also includes an isolated plurality of sequences which can identify one or more RISKMARKER or INJURYMARKER responsive nucleic acid sequences. The kit or plurality may include, *e.g.*, sequence homologous to RISKMARKER or INJURYMARKER nucleic acid sequences, or sequences which can specifically identify one or more RISKMARKER or INJURYMARKER nucleic acid sequences.

OTHER EMBODIMENTS

It is to be understood that while the invention has been described in conjunction with the detailed description thereof, the foregoing description is intended to illustrate and not limit the

scope of the invention, which is defined by the scope of the appended claims. Other aspects, advantages, and modifications are within the scope of the following claims.

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